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Editorial

New and Emerging Risk Factors in Occupational Health

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Abstract: Workplace health and safety is constantly evolving both in developed and developing countries. Under the tumultuous development of technology, working environments are changing, leading to the onset of new occupational hazards and unprecedented risk conditions deriving from the new ways of organizing work. At the same time, progress in medical science, with the knowledge in the fields of genetics, metabolomics, big data, and smart technologies, makes it possible to promptly identify and treat risk conditions that would have escaped notice in the past. Personalized occupational medicine represents the frontier of prevention in the workplace, from the perspective of total worker health and the sustainability of resources. The contributions to this Special Issue range from chemical, physical, and biological to psychosocial risks, and from the search for new ways to control long-known risks, such as mercury toxicity, to observations of the most frequent pathologies in the workplace in the last twenty years, such as repetitive trauma diseases, immunodeficiency transmitted as a result of biological injuries, and violence and psychological trauma in the workplace. New insights are needed in occupational health and safety practice to address the new challenges in this field.

Keywords: personalized prevention; total worker health; disability management; genetics; big data

1. Introduction

Working environments are constantly changing, leading to the onset of new occupational hazards. In developed countries, these include globalization; economic crisis; new technologies, forms of employment, and work organizations; as well as workforce aging. In developing countries, these include labor in the informal workplace, child labor in agriculture and mining, as well as unregulated and unprotected exposure to many traditional risk factors in the workplace.

2. Overview

Before examining the individual contributions gathered, a few general statistics and observations are useful to have an overview of the content and outreach of this Special Issue:

- Eight papers have been submitted for peer review, out of which seven were finally published, resulting in an acceptance rate of ≈87%.
- The average time to publish, intended as the time passed from submission to online availability, was 31.6 days, with a standard deviation of ≈14.7 days—dates are publicly available on each paper web page, accessible from the Special Issue home page (https://www.mdpi.com/journal/applsci/).

- Papers already generated an average of 447 full-text reviews.
- Published papers have been co-authored by authors coming from eight different countries, covering Europe, Africa, and North America. Amongst these, Italy and Spain are the most represented, with three papers with more than one local author.
- Figure 1 shows the word cloud generated from the full text of the published papers.

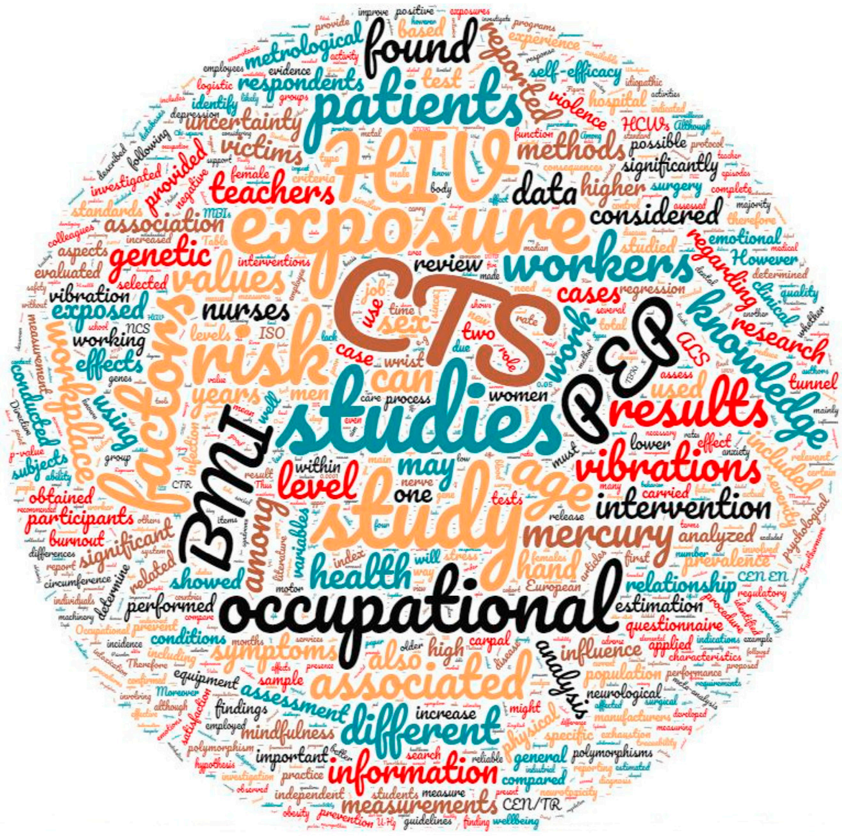

Figure 1. Word cloud generated from the full text of each publication of the Special Issue.

The most mentioned words were "occupational", "study", "studies", "risk", "factors", "exposure", and immediately after, by frequency, "knowledge", "workers", "workplace", "associated", "intervention", and "health".

The result is not surprising, and indicates that the theme of the Special Issue has been centered. The immediately less frequent words tell us what were the risk factors that the contributors faced, and what were the lines of interventions conducted on the workers.

Among the words that refer to individual occupational risk, we found "vibrations" and "CTS", (carpal tunnel syndrome), which refer to physical hazard; "mercury" and "genetics", concerning chemical hazard; "HIV" (Human Immunodeficiency Virus) and "PEP" (post-exposure prophylaxis), regarding biological hazard; and "teachers", "relationship", and "victims" concerning psychosocial factors in the workplace.

3. Knowledge on Individual Risk Factors

Physical hazards in the workplace attracted the attention of two research groups. Lorente-Pedreille et al. [1] underlined the methodologic limitation of current European standards concerning the estimation method of occupational exposure to vibrations. Workers exposed to vibrations and repetitive movements can develop chronic musculoskeletal conditions, such as carpal tunnel syndrome. Cazares-Manríquez et al. [2] have systematically reviewed the role of socio-demographic factors on the occurrence of the disease, concluding that the disease is associated with age, female sex, and a high Body Mass Index. Knowledge of the characteristics of the disease can provide indications for its prevention.

Among the chemical risks, two contributions dealt with a topic that has occupied occupational medicine for more than three centuries, mercury poisoning. The hazard is not new, but the knowledge on the factors that determine the risk and the indications for the personalization of prevention are. The occupational risk factor is elemental mercury vapors, an agent other than organic mercury, which is one of the major pollutants of the ecosphere. The importance of genetic factors on the onset of neurological pathology is demonstrated by studies conducted in the workplace, which have been systematically reviewed [3]. Studies conducted on workers exposed to mercury, predominantly in the dental care sector or gold processing, demonstrate the importance of polymorphisms. The occupational risk from metallic mercury is always combined with exposure to organic mercury present in the ecosphere, and genetic factors are critical in determining risk sensitivity or resistance. A case study is reported in which the presence of a genetic alteration in a maintenance worker from a chlor-alkali plant was associated with the recurrence of episodes of subacute mercury intoxication and finally with the appearance of amyotrophic lateral sclerosis [4].

Biological hazards in the workplace have also been known for some time, but the way they are addressed varies. The biological risk of the transmission of the agent of the acquired immunodeficiency has been known for over 20 years, but also in this case the implementation of prevention measures in the workplace requires a long and not simple cultural transition. The research by Rasweswe and Peu accounted for this development in South African nurses [5].

Psychosocial factors are the class of occupational risk agents that most recently attracted the attention of researchers. Acquadro Maran et al. [6] have analyzed the prevalence and characteristics of workplace violence against teachers and the consequences in terms of exhaustion and disengagement, lower levels of workplace satisfaction, and reduced emotional self-efficacy. Pérez-Fuentes et al. [7] showed that mindfulness-based interventions could contribute to providing workers with competencies and skills and develop their strengths, by improving their health, wellbeing, and quality of life. A few years ago, these hazards were collectively referred to as the "fourth group of risk factors" to mean that it was something different from the classic occupational hazards—chemical, physical, and biological—which occupational medicine had been studying for three centuries. The most modern observations tell us how, in reality, these risk factors act in a complex and difficult to disentangle interrelation with others.

4. Development Prospects

The studies accepted in this issue trace the lines towards which occupational health can be developed. Individual differences in occupational disease risk, previously considered to be idiopathic, currently seem clearly linked to differing susceptibilities arising from genetic polymorphisms among individuals. The growing understanding of these genetic predispositions and the effect of environmental influences seem to suggest that many occupational disorders share causal roots in gene–environment interactions. Genetics, through the study of polymorphisms and epigenetic variations, may indicate new personalized prevention strategies, with the adoption of more stringent safety measures in favor of hypersensitive workers. Despite the rapid progress in these fields, further work is necessary before gene expression changes can be used to establish safe levels of substance exposure. In the future, we will probably strive to link gene expression changes and pathway perturbations to the phenotype by mapping them to specific adverse outcome pathways [8]. Although no specific genetic assays for routinely testing occupational disease susceptibility have been so far marketed, the rapid pace of research in this field will probably make such assays available in the next years [9]. Some epigenetic mechanisms involving the silencing of tumor suppressor genes and/or the activation of proto-oncogenes, which are considered critical during carcinogenesis, have been observed in many occupational-induced human cancers [10,11]. Biomarkers could be linked to disease susceptibility and progression, as well as provide a significant tool for identifying the pre-clinical effects of environmental chemical, physical, and biological pollutants. The future target of safety in the workplace will not only be to guarantee the absence of occupational diseases, as it was in the last century, but to demonstrate the absence of epigenetic variations in the exposed workers. From this perspective, telomeres and their interacting proteins [12] and micro RNAs mutations [13] are among the most likely candidates as potential biomarkers for exposure and health response to physical, chemical, or psychosocial occupational stressors, including redox regulatory changes and oxidative stress. Epigenetic investigations with a special focus on gene–environment interactions are currently exploring the relationship of various occupational stressors with internal biological systems, with reference to resilience or susceptibility to stress [14]. The traditional separation between physical-chemical and psychosocial agents is outdated. Workplace interventions of health promotion will probably target the relationship between work-related stress and epigenetic plasticity factors in a holistic view.

The new concept of "Total Worker Health" (TWH) was developed from this very wide perspective. TWH is articulated into a complex of policies, programs, and practices that integrate protection from work-related safety and health hazards with the promotion of injury and illness prevention efforts to advance worker well-being [15]. This holistic model prioritizes a "hazard-free work environment for all workers". The paradigm needs to maximize worker health, safety, and well-being and is based on inclusive physical, social, economic, psychological, and spiritual health components of well-being [16]. This approach needs to continue addressing deadly hazards and risks that may occur in sectors where traditional occupational health and safety practices are still necessary, but also considering non-working origin risk factors that could create a synergy with occupational ones [17].

In the workplace, we have achieved in recent years a progressive and very strong reduction in the levels of chemical and physical pollutants. At the same time, however, in these environments the number of pollutants present in low doses has increased enormously. Furthermore, awareness of the importance of organizational and psychological factors has increased. Work environments have become much more complex than they used to be. Furthermore, individual risk depends on the interaction of occupational risk factors with environmental ones outside the workplace. Hence, there is a need to develop a new analysis paradigm that includes, in addition to the sequencing of the genome, also the study of the exposome—i.e., a detailed map of all the occupational and environmental components to which an individual is exposed during his/her life. The analysis of the exposome can help predict the biological responses of the organism to environment over time. Advances in "omics" techniques, metabolomics, metagenomics, proteomics, and systems biology are allowing researchers to gain unprecedented insight into the physiological ramifications of human behavior. Various omics technologies could be used to identify biomarkers of internal exposure and biological effect, while new sensor technology will efficiently measure external dose [18]. Molecular Big Data, coming from wet-lab techniques where drugs, chemicals, and other types of biological matter that can be analyzed and tested using various liquids, as well as Computational and Digital Big Data coming from a dry lab focused on applied or computational mathematical analyses and computer-generated models or simulations infrastructures (including databases, sensors, and smart devices), can help us to analyze the relationships between occupational and environmental exposures and work-related diseases, uncovering new risk factors and supporting preventive workplace practices [19].

The effects of the robotic industrial revolution, so-called "Industry 4.0", will profitably include certain disadvantages categories, such as people with disabilities, in the productive process, overcoming physical and even gender differences. On the other hand, there will be an increased risk of occupational marginalization and work shortage [20]. Far-reaching interventions will be needed to limit the social impact of the transformations and to reduce the possibility that robotics could enhance work-related stress factors such as privacy invasion, reduced human-to-human contact, and mental overload. The first studies on workers using robotic technologies, however, have not found a worsening of satisfaction, wellbeing, and quality of life [21]. The danger of a progressive loss of human–nature interactions typical of current civilization, the so-called "extinction of experience" [22], however, remains, and its consequences could be studied with objective markers of stress physiology and the microbiome. At the same time, planetary health as an emerging multidisciplinary concept will be strengthened by input from the perspectives of physiological anthropology. However, in order to advance such findings into planetary health discourse, it will be necessary to further understand how these biological responses (inflammation and the collective allostatic load) are connected to psychological constructs, such as nature relatedness and pro-social/environmental attitudes and behaviors [23].

The conviction emerges that technological transformation must be guided to avoid it ending up increasing inequalities between countries and between social categories [24]. The profound differences between countries in the levels of regulatory protection of occupational health and safety that exist today [25] must be corrected and not accentuated. The contribution of occupational health and safety services will have increasing importance in facing the problems of the coming years, such as global warming [26] and the aging of the workforce [27,28]. This rapid increase in the age of employees took place in recent years without it being possible to promptly change the workplace, with the consequence that even today many elderly and chronically ill workers are forced to carry out tasks designed for young people. An adaptation of the workplace is essential. At the same time, it is necessary to plan interventions to promote the health of workers and to recover from disabilities. Disability management, an indispensable tool to ensure job retention and job reintegration for workers with chronical disease, will receive the support of the new technologies that allow the real-time control of health conditions and must be integrated with interventions that increase the participation of workers and their work engagement [29]. A participatory approach, indeed, has numerous advantages over the more common top-down approach in managing workplace transformations [30].

5. Conclusions

Occupational medicine was born when the first scientific revolution made available a new method of medical investigation and new technologies that exposed workers to unprecedented hazards.

Today, occupational health is grappling with the fourth Industrial Revolution, an epochal change in perspectives and potential. Once again, technology will bring both risks and the ability to control them more effectively. The future of work will likely involve a mixture of traditional (e.g., chemicals, physical, radiological, and biological agents), current (repetitive work, manual material handling, psychosocial hazards), and new hazards (e.g., human interaction with robots). Globalization will lead new technologies and risk factors in both developed and developing countries. As called by the ILO (2019), a more "human-centered" agenda for the future of health and safety at work shall address not only traditional hazards in a single job but also along the work–life continuum by a complex and overall strategy, including interdisciplinary, multidisciplinary, and transdisciplinary approaches [17], where professional contributions from many disciplines, including applied economics, sociology, gerontology, informatics, education, climate science, sustainability, and others, will be required.

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