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Occupational health and safety in the industry 4.0 era: A cause for major concern?

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ABSTRACT

Real-time communication, Big Data, human–machine cooperation, remote sensing, monitoring and process control, autonomous equipment and interconnectivity are becoming major assets in modern industry. As the fourth industrial revolution or Industry 4.0 becomes the predominant reality, it will bring new paradigm shifts, which will have an impact on the management of occupational health and safety (OHS).

In the midst of this new and accelerating industrial trend, are we giving due consideration to changes in OHS imperatives? Are the OHS consequences of Industry 4.0 being evaluated properly? Do we stand to lose any of the gains made through proactive approaches? Are there rational grounds for major concerns? In this article, we examine these questions in order to raise consciousness with regard to the integration of OHS into Industry 4.0.

It is clear that if the technologies driving Industry 4.0 develop in silos and manufacturers' initiatives are isolated and fragmented, the dangers will multiply and the net impact on OHS will be negative. As major changes are implemented, previous gains in preventive management of workplace health and safety will be at risk. If we are to avoid putting technological progress and OHS on a collision course, researchers, field experts and industrialists will have to collaborate on a smooth transition towards Industry 4.0.

1. Introduction

Industrialisation has undergone remarkable transformations since its beginnings in the 18th century. Following the introduction of machinery powered by local generation of steam, which uncoupled production from the limitations of human manual effort (Industrial revolution 1.0), the next paradigm shift came in the 19th century with the introduction of electricity, which allowed the broad distribution of power from a central facility. Thanks to electricity, machinery became less bulky and ran faster (Industry 2.0). The 20th century brought powered assembly lines, and with the development of electronics, manufacturing became more and more automated (Industry 3.0) and focused on performance. With automation came opportunities to optimise manufacturing processes and improve productivity through the design of more flexible, ergonomic and safer machinery (MESI, 2016).

In comparison, the term "Industry 4.0" was coined very recently. As might be expected, it refers to the convergence of manufacturing with the digital revolution, artificial intelligence, the Internet of things and with every device called "smart". Its goal is to allow manufacturers to meet ever-changing demand more efficiently using adaptable and responsive machinery. This idea goes beyond the design of single machines and now encompasses a broadened vision that can best be described as a global revolution in manufacturing. Conceived in Germany, this vision has spread to several other industrialized countries, some of which have been investing heavily in order to catch up to the innovators (MacDougall, 2014; MESI, 2016). Real-time communication, Big Data, man–machine cooperation, remote sensing, monitoring and control, autonomous equipment and interconnectivity are all considered as non-negligible assets in industries that face fierce competition and seek to improve productivity and reduce costs.

The fourth industrial revolution goes well beyond concepts such as interconnectivity and digital manufacturing. In Industry 4.0, businesses digitize their physical assets and integrate them into digital ecosystems throughout the value chain. Industry 4.0 promises increases in productivity through the integration of digital systems of production with analysis and communication of all data generated within an intelligent environment.

In examining these transformations, we note a co-evolution of manufacturing philosophy and the approach to occupational health and safety (OHS). Industrialisation created an urgent and growing need for

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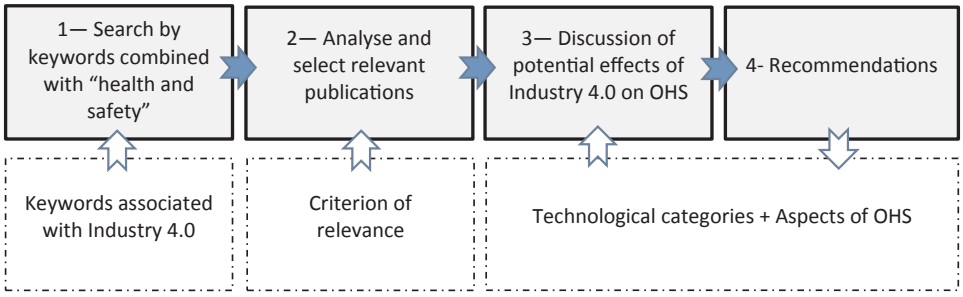

Fig. 1. Methodological steps.

labour and led to the rise of deplorable working conditions in which men, women and children risked life and limb to earn their keep. The inexperience of the labour force and the ignorance of employers regarding what we now call OHS inevitably took a brutal toll, and under the resulting public pressure, legislators were forced to intervene. Labour unions, labour laws, regulations and standards began gradually to emerge in industrialized countries. Although some alarming statistics persist, it is now safe to say that workplace conditions have improved tremendously. Notwithstanding continued criticism, we can also point to improved involvement of employers and workers in the solving of problems related to OHS. Today, we refer to integrated OHS management, sophisticated tools and standards for the management of occupational risks, equipment that is safer to operate, and especially working environments and practices that are better supervised and controlled.

It should be emphasized that evolution in the realm of OHS has always followed revolutionary developments in industry. Reaction to technological progress, changes in work methods and the real consequences of these on OHS have provided the impetus for the implementation of reliable and sustainable solutions to problems. In most industrialized countries, reactivity is now yielding to proactivity, which has advanced considerably during recent decades but has also benefitted from legislation, regulation and standards that have brought to the forefront both occupational risk and the duty to eliminate danger at the source. Prevention is no longer just a word. Industrial businesses today now understand that the health and safety of their workers is a major component of financial success, like total quality, productivity and cost reduction. A healthy business is now one in which OHS is regarded as an imperative.

As Industry 4.0 becomes more and more a reality, it appears inevitable that it will lead to a new series of paradigm shifts. We are starting to see the implementation of new industrial concepts based on decentralising of information and decision-making. Industrialists are starting to evaluate the positive repercussions on the responsiveness, autonomy and flexibility of manufacturing facilities. New generations of interconnected and autonomous equipment such as cobots (collaborative robots) are emerging (MESI, 2016; Beetz et al., 2015). All of this is intended to meet human needs that never cease to diversify. This is observable at the numerous congresses, trade shows and workshops that promote this industrial effervescence and further stimulate competitiveness.

As this trend gathers momentum, we must ask whether or not we have we given sufficient thought to new OHS imperatives. Have we evaluated the OHS consequences (positive and negative) of this industrial revolution? Will we lose the gains made through proactivity? Will OHS considerations have any moderating influence on all this effervescence? Are there reasonable grounds for apprehension? By raising such questions, our intention in this article is to initiate reflection with regard to the integration of OHS into Industry 4.0. We shall begin with a description of our research methodology in the next section, followed by the results of our analysis of the literature relating to OHS in the context of Industry 4.0. In the fourth section, we present a broader discussion of the potential effects of Industry 4.0 technologies on OHS, we list some of the recommendations found in the literature and we point out the current limitations of research in this area, including our own. In the fifth and final section, we present our conclusions.

2. Methodology

2.1. The context

The term "Industry 4.0" thus refers to the fourth industrial revolution. Other expressions such as "industrial internet" or "digital manufacturing" refer to similar ideas but do not convey the whole picture. In fact, the disparity of the usable terms is the first obstacle to overcome in carrying out an exhaustive search of the literature. For this purpose we consulted a list of equivalent terms published recently (Danjou et al., 2017), from which we selected those that appeared to be the most widespread, namely: "industrie 4.0", "industry 4.0", "manufacturing 4.0", "smart production", "smart manufacturing", "smart factory", "smart industry", "factory of the future" and "advanced manufacturing".

2.2. Steps of the review

In order to achieve our objective, the review was carried out according to the steps shown in Fig. 1.

The first step consisted of a systematic search for publications using the selected keywords. During this step, we used only the keyword "health and safety" since it is the most representative and inclusive term in the OHS field. This keyword was combined (OR, AND) with the terms most widely associated with Industry 4.0, as mentioned above.

The fields of text searched included the title, the abstract and the keywords of peer-reviewed articles published since 2012. For this purpose, we used only the cross-disciplinary database Scopus, which is the largest database of peer-reviewed publications and includes scientific reviews, collections of works and conference proceedings.

The second step consisted of selecting publications focused on OHS in the context of Industry 4.0. Each researcher analyzed independently each of these articles, and all findings were discussed in a meeting in order to establish their reliability, which was judged according to the vested interest the authors might have had in discussing OHS through the developments they achieved in association with Industry 4.0.

The third step was devoted to complementing the initial literature search results with a broader discussion of the effects (positive or negative) of Industry 4.0 on worker health and safety in view of the technological categories listed in Table 1, namely Big data, Internet of things, cyber-physical systems, computer networks, cobotics, artificial intelligence and computer simulations (Danjou et al., 2017; Hermann et al., 2016). This discussion was based also on four aspects of OHS, namely: (1) organisation of work, (2) OHS legislative and regulatory framework, (3) OHS management systems and (4) management of occupational risks. In order to support the ideas formulated during the discussion, more extensive literature published since 2010 was