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Theoretical framework for the new and emerging occupational risk modeling and its monitoring through technology lifecycle of industrial processes

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ABSTRACT

Besides traditional occupational risks (TR), industrial processes can generate other risks described by the European Agency for Safety and Health at Work (EU-OSHA) as “new and emerging risks” (NER).

The basic definition of NER is that of “*any occupational risk that is both new and increasing*”, existing several studies carried out by the EU-OSHA where the set of the above mentioned risks is identified and analyzed, both general and specific.

However, as demonstrated in recent studies, the direct use of this set of NER in risk assessment techniques, generally applied in industrial processes and in particular those characterized by advanced technology, may result in the identification of TR instead of NER, mainly due to the fact that they have been defined without following a risk reference model.

In order to solve this problem, a risk model that improves and complements the EU-OSHA’s NER definition has been developed with the abovementioned investigations. However, this model has two limitations. First, the model does not contemplate the possibility of considering independently the new risks (NR) and increasing risks (IR). Second, this model does not allow monitoring NER evolution over time, therefore it is not currently possible to determine, in general, the temporary validity of such risks.

Thus, the main objective of this work is to develop a theoretical framework for the modeling of the NER that allows its monitoring through the technology lifecycle (TLC), especially in industrial processes.

To develop this framework, first it has been carried out an analysis of the limitations previously mentioned as well as the related literature. In this way, a theoretical context that allows to justify and argue properly the development of three new models for the NER, NR and IR has been set up.

These named models allow, on the one hand, characterizing and differentiating the new qualities from the increasing qualities associated to risk. On the other hand, these models allow defining a set of risk typologies. These typologies have been associated with risk evolutionary phases likely to be integrated into the TLC, especially of a given industrial process, allowing monitoring over time of its NER.

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1. Introduction

The new industrial processes are characterized by innovative variables of a technological and organizational nature which tend to change with workplaces, processes and conventional work practices, and can generate, as well as traditional occupational risks (TR), other so-called new and emerging risks (NER). This raises new challenges for workers and companies, and in turn creates political demands, administrative and technical approaches that

ensure high levels of safety and health at work (adapted from EU-OSHA, 2013).

The European Agency for Safety and Health at Work (EU-OSHA) (Rial-Gozález et al., 2005; Achter and Degrand-Guillaud, 2006; Savolainen and Sas, 2006) and the International Labour Organization (ILO, 2010) indicate the need for research in the field of NER, looking at alternatives when they are the result of new technologies, work processes or substances. In this context, in the prospective study on NER associated with new technologies in 2020, published by the EU-OSHA (Ellwood et al., 2014), “Green manufacturing technologies and processes, including robotics and automation” were selected from the eight new technologies that could help create NER in green jobs by 2020.

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In the manufacturing industry, the National Institute for Occupational Safety and Health of the United States (NIOSH) has developed through NORA (National Occupational Research Agenda) a set of objectives in order to improve the knowledge regarding NER in this industry (NORA, 2010; NIOSH, 2010).

In relation to robotics, its spread presents both opportunities and challenges, from the general point of view of occupational safety and health (OSH). The greatest OSH benefits stemming from the wider use of robotics should be substitution for people working in unhealthy or dangerous environments. However, the introduction of human enhancement technologies raises new demands on health and safety management to monitor emerging risks (EU-OSHA, 2015a).

In general it can be claimed that society has progressed from information society to knowledge society and from knowledge society to ubiquitous knowledge society. In ubiquitous society the role of smart and autonomous machines will be a key issue. Technology waves like digitalization, information and communication technology (ICT) and robotics are crucial elements of the new ubiquitous society (Kaivo-oja, 2015).

The potential impact of ICT on work and OSH takes three forms. First is the emergence of new technologies which may affect how people do their jobs (e.g. individual devices attached to clothing which can monitor worker's movements and physiological state), second is the growth of existing technologies (e.g. mobile IT devices), and third is developments and evolutions in how technology enables organisations to structure themselves and to organise work (Cox et al., 2014).

From a more general view, in the EU Occupational Safety and Health (OSH) Strategic Framework 2014–2020 (EC, 2014), it is seen as one of its three major challenges to improve the prevention of work-related diseases by tackling new and emerging risks without neglecting existing risks.

In this paper the NER definition adopted by the EU-OSHA, which has been integrated, with certain modifications, in the CWA 16649: 2013 document published by the CEN (European Committee for Standardization) on the management of risks related to emerging technology shall be taken as reference.

However, this definition has been developed without following any risk model reference, thus hindering its use in the NER identification and analysis (Brocal and Sebastian, 2015a,b). To solve this problem, Brocal and Sebastian (2015a) have developed a new risk model whose objective is to characterize the NER. Nevertheless, this model has two limitations. First, the model does not contemplate the possibility of considering independently the new risks (NR) and increasing risks (IR). Second, this model does not allow monitoring the evolution of NER over time, therefore it is not currently possible to determine, in general, the temporary validity of such risks.

The main objective of this study is to develop a theoretical framework for the NER modeling and monitoring, considering its different evolutionary phases in contexts of change, of a technological and organizational nature, especially associated with industrial processes. From this general objective, two specific objectives are derived. With the first one the aim is modeling the different evolutionary phases covered since the risk can be considered new until it can be considered, finally, traditional. With the second specific objective, the purpose is to integrate these evolutionary phases in the TLC, and thus allowing the NER monitoring over time.

In order to develop such framework, an analysis of the limitations mentioned before, as well as the related literature will first be carried out. Thus, it is intended to set up a theoretical framework that justifies and argues properly the further development of two new models, one for the NR and another for the IR.

The purpose with these models is, on the one hand, to characterize and differentiate the new qualities from the increasing qualities. On the other hand, with these models is intended to define a set of risk typologies. These typologies will be associated with evolutionary phases capable of integrating into the TLC, especially of a given industrial process, thus allowing the monitoring of its NER.

2. Description of the NER conceptual and evolutionary problem

The agency's first step in the identification of specific NER with the publication of four reports on experts' forecasts, which make up the basis of this study, covering physical risks (Flaspöler et al., 2005) biological (Brun et al., 2007a), psychosocial (Brun et al., 2007b) and chemical (Brun et al., 2009), followed by numerous literature reviews and detailed reports designed to explore the main risks identified in the above projections (EU-OSHA, 2013).

EU-OSHA defines NER through the reports cited as listed below by definition 1. In this definition 1, unlike the original sources cited, it is the codification (Ci), which in this paper is called "conditions" that define a NER.

Definition 1 (NER). Any occupational risk that is both new and increasing (Flaspöler et al., 2005; Brun et al., 2007a, 2007b, 2009):

- By «new» it is meant that:
 - C1. The risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change; or,
 - C2. A long-standing issue is newly considered as a new risk due to a change in social or public perceptions; or,
 - C3. New scientific knowledge allows a long-standing issue to be identified as a risk.
- The risk is «increasing» if the:
 - C4. The number of hazards leading to the risk is growing; or
 - C5. The likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/or the number of people exposed); or
 - C6. The effect of the hazard on workers' health is getting worse (seriousness of health effects and/or the number of people affected).

However, as shown in the research by Brocal and Sebastián (2015a,b) the direct use of the NER collected in the reference studies (Flaspöler et al., 2005; Brun et al., 2007a, 2007b, 2009), often impedes the distinguish between those coinciding with TR and those that can be truly considered as new and emerging, according to the definition adopted by the EU-OSHA. In this sense, among the latest data published by the EU-OSHA, it emphasizes the European Survey of Enterprises on New and Emerging Risks (ESENER) second edition (EU-OSHA, 2015b). However, being very valuable these results in the general field of OSH, after analyzing them, it is not possible to distinguish between NER and TR (Brocal, 2016).

Similar problems have been identified with the iNTeg-Risk project, finished in 2013. With respect to this, Jovanović and Baloš (2013) indicate that in the forthcoming phases of the project iNTeg-Risk, it will be essential to take into account factors like specific aspects of emerging risks, i.e. the differences in comparison with conventional risks.

To correct this problem, that is to say, in order to distinguish between the NER and TR, Brocal and Sebastian (2015a) have developed two new risk models. The first risk model, described in definition 2, has been developed from the EN 31010: 2010 and ISO 31000:2009. Thus, as is clear from Eq. (1), the structure that configures a particular risk is generally possible to characterize in a qualitative or semi-quantitative form.

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