Occupational health and safety management systems: opportunities and challenges

Sistemas de gestão de saúde e segurança no trabalho: oportunidades e desafios

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ABSTRACT
This study aimed to support researchers' reflective analysis and to identify unexplored topics as possibilities for future research with practical importance

about occupational health and safety management systems (OHSMSs). The paper investigates OHSMSs literature by assessing the development of the field and identifying evolution patterns and gaps. With a qualitative approach, this systematic review was developed with the adoption of bibliographic procedures and action research. The intervention instrument *ProKnow-C*, a structured process guided by the constructivist perspective, was used. 3,130 studies were analyzed. Based on the results, the paper identified prolific authors and the most studied economic sectors. The evolution of safety management systems goals is explained and the evolutionary movement of the systems is compared to Bititci´s. A literature map was illustrated to show the frequency that the aspects related to OHSMSs are being explored. It indicates that integrated systems and ergonomic aspects are the most discussed topics. Furthermore, there is a shortage of longitudinal studies. It is noteworthy to mention that ergonomic indicators are being introduced into OHSMSs and their correlation is a promising topic to be explored. The use of data science, artificial intelligence and machine learning has grown significantly and quickly and has contributed to the evolution of the area. We conclude that developing OHSMS by respecting the decision maker's knowledge throughout the process, incorporating ergonomic aspects and using AI methods is a challenge that will contribute to the advancement of OHSMSs.

Keywords: data science, ergonomics, occupational safety, performance evaluation.

RESUMO

Este estudo teve como objetivo apoiar a análise reflexiva dos pesquisadores e identificar tópicos não explorados como possibilidades para futuras pesquisas com importância prática sobre sistemas de gestão de saúde e segurança ocupacional (OHSMSs). O artigo investiga a literatura OHSMSs avaliando o desenvolvimento do campo e identificando padrões de evolução e lacunas. Com uma abordagem qualitativa, esta revisão sistemática foi desenvolvida com a adoção de procedimentos bibliográficos e pesquisa de ação. Utilizou-se o instrumento de intervenção ProKnow-C, processo estruturado orientado pela perspectiva construtivista. Foram analisados 3.130 estudos. Com base nos resultados, o trabalho identificou autores prolíficos e os setores econômicos mais estudados. A evolução dos objetivos dos sistemas de gestão da segurança é explicada e o movimento evolutivo dos sistemas é comparado ao de Bititci. Um mapa da literatura foi ilustrado para mostrar a frequência com que os aspectos relacionados aos OHSMSs estão sendo explorados. Indica que os sistemas integrados e os aspectos ergonômicos são os tópicos mais discutidos. Além disso, faltam estudos longitudinais. Vale ressaltar que indicadores ergonômicos estão sendo introduzidos nos OHSMSs e sua correlação é um tópico promissor a ser explorado. O uso da ciência de dados, inteligência artificial e aprendizagem de máquina tem crescido significativamente e rapidamente e tem contribuído para a evolução da área. Concluímos que desenvolver os OHSMS respeitando o conhecimento do tomador de decisão ao longo do processo, incorporando aspectos ergonômicos e usando métodos de IA é um desafio que contribuirá para o avanço dos OHSMSs.

Palavras-chave: ciência de dados, ergonomia, segurança ocupacional, avaliação

de desempenho.

1 INTRODUCTION

Risks are relentlessly involved in any business activity. In other words, there is no such thing as “zero risk” (Mearns & Håvold, 2003). Occupational health and safety (OHS) is not an exception. OHS is one of the most important branches in management systems (MS), as its absence may have serious consequences, such as causing occupational illnesses or accidents, or deaths, increasing absenteeism rates and injury claims, reducing effectiveness, discrediting the company's image with customers and investors and leading companies into bankruptcy.

The OHS system is an integral part of an organization that includes a set of technical and organized measures and activities, which aim at achieving safety at work, eliminating and preventing hazards/ harmfulness that can cause occupational injuries, occupational and other diseases and protecting health and working capacity of workers (Vranjes & Todic, 2019). It comprises a set of policies and practices aimed at positively implicating the employee’s attitudes and behaviors with regard to risk to reduce their unsafe acts (Beriha, Patnaik, & Mahapatra, 2011).

Health Safety and Environmental (HSE) Management Systems play an important role in the enhancement of safety and human and organizational productivity (Azadeh, Farmand, & Sharahi, 2012). To achieve excellence in prevention, safety must be integrated into all the organization’s decisions and actions, and it must be more organizational and strategic than material (Fernandez-Muniz et al., 2009).

Accidents not only incite a decrease in human capital but also generate financial losses due to disruptions in industrial processes, damage to production machinery, and harm firm’s reputation (Beriha et al., 2011). Therefore, HSE programs attempt to decrease workplace injuries, health issues and severe effects to environment (Azadeh, Saberi, Rouzbahman, & Valianpour, 2015).

By considering health, safety, environment and ergonomics (HSEE), an organization manages to regulate, standardize and optimize its operations in a manner that places safety and health first (Asadzadeh, Azadeh, Negahban, &

Sotoudeh, 2013). HSEEs are important concepts in today's industries for managers because this will lead to providing a safe and healthful working environment for all workers as well as the public (Azadeh, Rouzbahman, Saberi, & Valianpour, 2014; Azadeh, et al., 2015).

Performance Evaluation (PE) finds a fertile field in occupational health and safety (OHS), as there is no consensus on aspects such as definition, indicators, models, goals, ways to be measured and evaluated. This lack of uniformity already arouses the interest of researchers *de per si*. According to Köper, Möller, & Zwetsloot (2009), there is still a lack of theoretical foundation and generally accepted standards in theory, models, or business cases.

Therefore, the purpose of this study is to draw insights based on a systematic review of the literature displayed in this area to support researchers in their reflective analysis and the identification of unexplored topics and possibilities for future research. To achieve this goal, the *Knowledge Development Process-Constructivism* (*ProKnow-C*) (Staedele, Ensslin, & Forcellini, 2019; Thiel, Ensslin, & Ensslin, 2017) was chosen. It is a structured process for analyzing the literature, in which the philosophical basis is constructivist and aligned with the objective of this research.

This research is justified by the importance of providing a holistic view of some characteristics of the studies conducted in the area of OHSMSs. It contributes to consolidating the existing knowledge, making unexplored topics explicit, encouraging new research and generating subsidies to help company managers in the elaboration of OHSMSs.

The delimitation for this research was established through inclusion and exclusion criteria, such as (i) articles published in English; (ii) scientific journals; (iii) search commands in the titles, abstracts, and keywords; (iv) Scopus and Web of Science databases; and (v) without time limitation.

2 RESEARCH METHODOLOGY

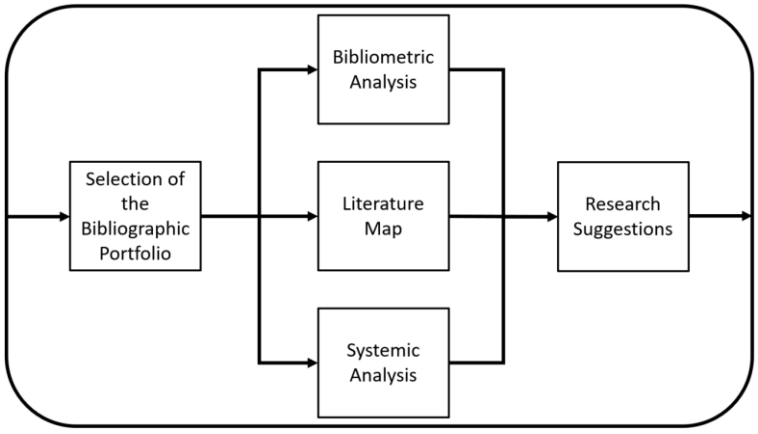
This study is considered exploratory and it was developed with the adoption of bibliographic procedures and action research. The methodological procedures are divided into three sections. The first one presents the intervention instrument; the second demonstrates the selection process of the bibliographic portfolio and

the third section explains the procedures used to analyze the data.

2.1 INTERVENTION INSTRUMENT

The intervention instrument used was the *Knowledge Development Process-Constructivist* (*ProKnow-C)*. It is a structured process that aims to develop knowledge in the researchers and transmit it through the analyzes and contributions (Dutra, Ripoll-Feliu, Fillol, Ensslin, & Ensslin, 2015) according to the delimitations established by the researcher. The instrument is constantly being updated and currently consists of five stages: (i) selection of the bibliographic portfolio (BP); (ii) bibliometric analysis; (iii) literature map; (iv) systemic analysis; and (v) formulation of research suggestions. Figure 1 shows the macro-processes within *ProKnow-C*. This study was performed with the following stages: (i) selection of the bibliographic portfolio (BP); (ii) bibliometric analysis; (iii) literature map; and (v) formulation of research suggestions.

Figure 1: ProKnow-C macro-process (Welter & Ensslin, 2021)



2.2 DATA COLLECTION PROCEDURES

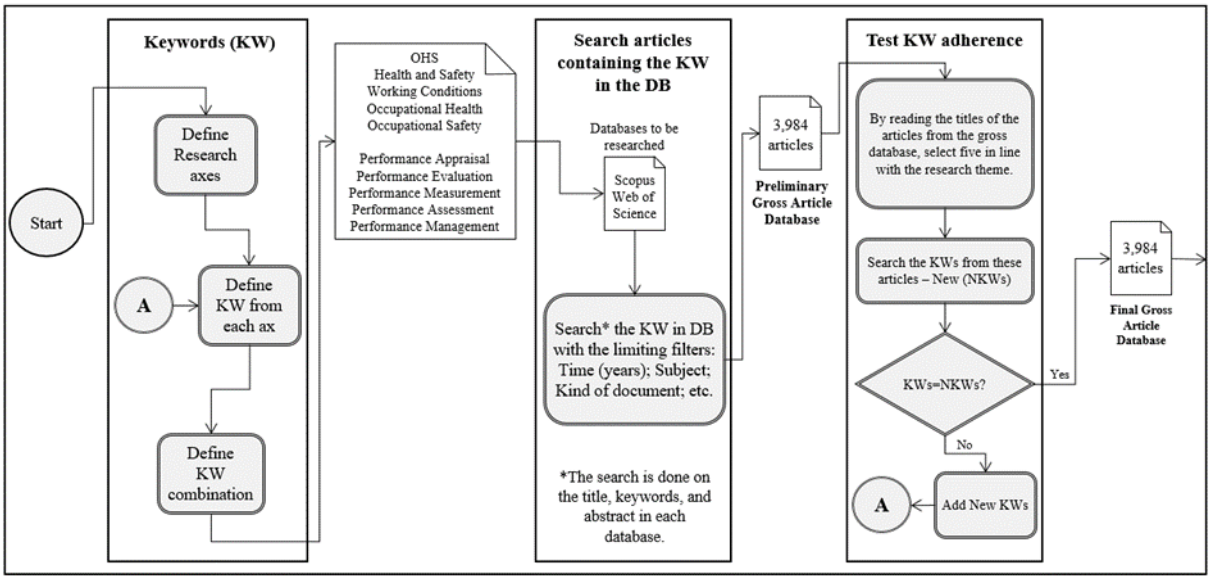
2.2.1 Data collection procedures

To choose the bibliographic portfolio (BP) to represent the reviewed literature, three steps were taken: (i) selecting articles to create the gross article database; (ii) Filtering to remove redundancy, misaligned titles and articles without scientific recognition; (iii) abstract reading and potential scientific recognition filter; and (iv) complete reading article filter.

In the first step, two research axes were defined as performance evaluation and occupational health and safety. Their keywords were used to select the gross

article database (as shown in Figure 2). Their combinations were used to search in the databases *Scopus* and *Web of Science*, on 21 October 2021. The title, abstract and keywords of each hit article were used. There was no use of temporal delimitation. After the first search, 3,984 articles (1,069 were obtained from *Web of Science* and 2,915 from *Scopus*) were collected and used to form the preliminary gross article database. The adherence test was performed to verify the representativeness of these keywords. Accordingly, five articles with titles aligned were selected and their abstract and keywords were analyzed to verify if new keywords need to be added. There were no representative keywords different from the first one used. Consequently, no keyword was added.

Figure 2: Gross article database articles selection



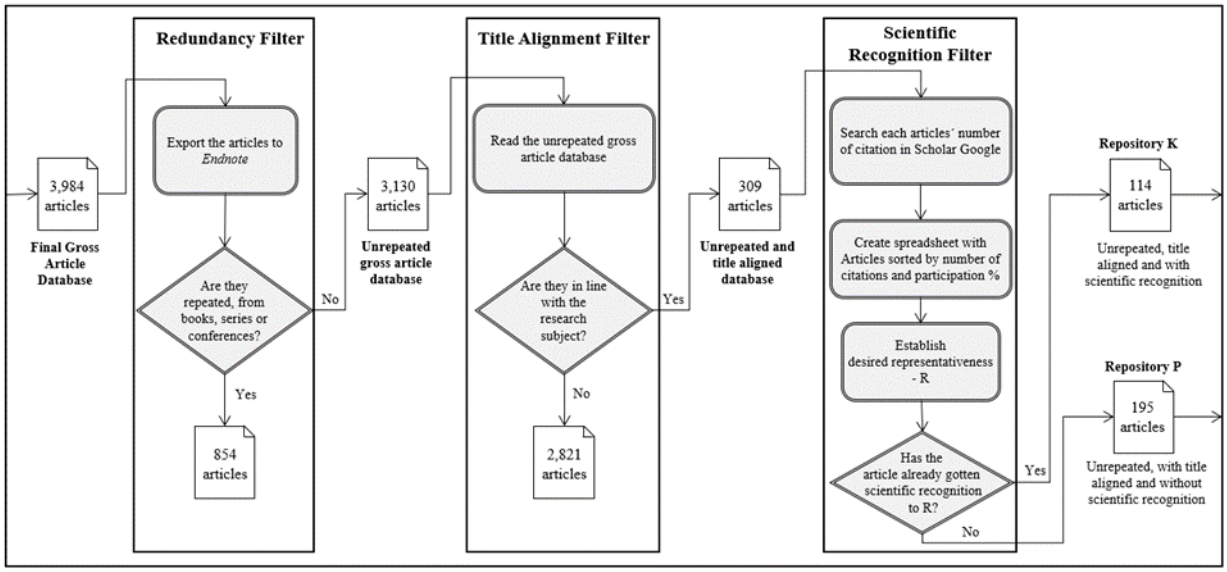
Source: Elaborated by the authors.

The redundancy, title and scientific recognition filter steps are shown in Figure 3. Data containing titles, authors, abstracts, names of journals and institutions, and keywords of the articles were exported to the bibliographic manager software *Endnote X9*. Publications from books and chapters, series, conferences and duplicated articles were excluded. 854 articles were excluded from the analysis and 3,130 articles composed the unrepeated gross articles database. Next, the titles were analyzed. The articles were deleted when their titles were not clearly aligned with the research topic.

There were 309 remaining articles from which the number of citations was obtained through *Google Scholar* to verify the articles' scientific recognition. The

percentage of the citations of each one was calculated within the whole. The desired representation rate (R) was set at 26 or more citations. There were 114 articles above that criterion representing 88% of all citations (repository K). 195 articles, which were below the desired representation rate, became part of the database named unrepeated articles with title aligned and with potential to have scientific recognition (repository P).

Figure 3: Redundancy, title, and scientific recognition filters



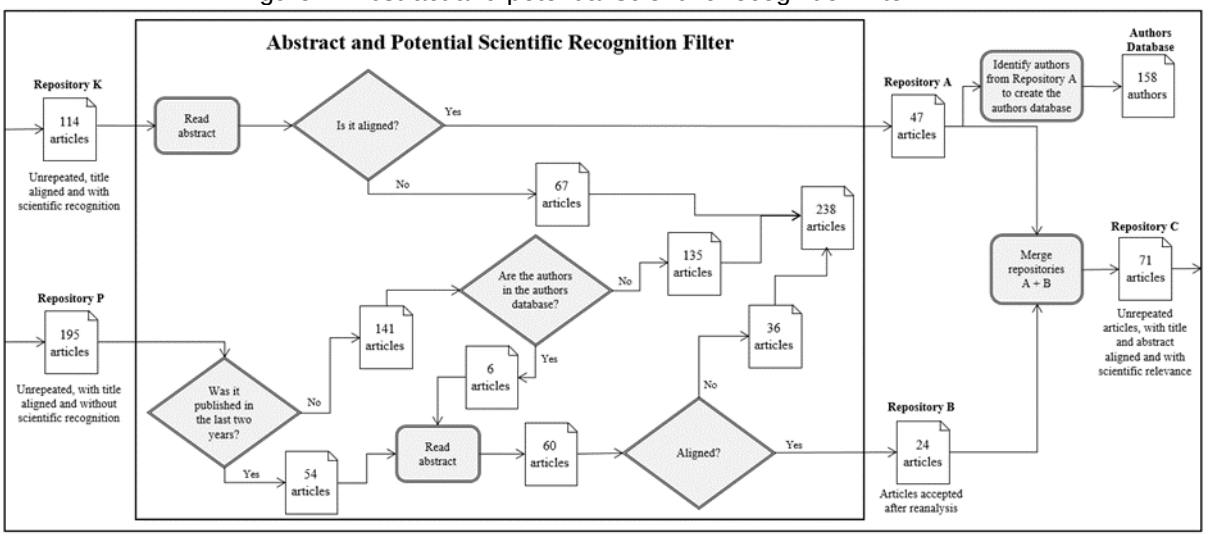
Source: Elaborated by the authors.

Abstract and potential scientific recognition filter is shown in figure 4. 114 abstracts from repository K were read and 47 articles were considered aligned. These unrepeated articles, with titles and abstracts aligned and confirmed scientific relevance formed repository A. From repository A, 158 different authors were identified and the authors' database was created.

54 articles published in the last two years were considered recent and were reanalyzed. From the 141 (not recent), it was verified whether the authors were part of the authors' database. 6 articles were found. The abstracts of the 6 articles and the 54 recent articles were read. 24 articles were aligned and were accepted for reanalysis, forming repository B.

Articles from repositories A and B were grouped in repository C. It contains 71 unrepeated articles, with the title and abstract aligned and with scientific relevance.

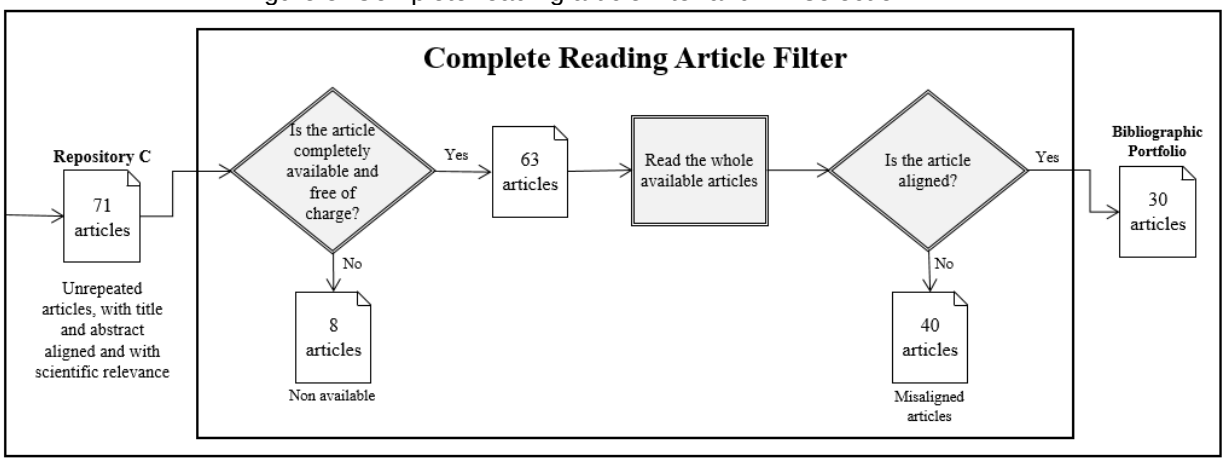
Figure 4: Abstract and potential scientific recognition filter



Source: Elaborated by the authors.

63 were completely available and free of charge as shown in figure 5. After reading them totally, 30 aligned articles remained and comprised the BP. These articles can be found in the references section, with sequential numbering from 1 to 30 between [ ].

Figure 5: Complete reading article filter and PB selection



Source: Elaborated by the authors.

2.3 DATA ANALYSIS PROCEDURE

After the selection of the BP (Stage 1), the bibliometric analysis (Stage 2) was carried out. It aims to identify and highlight the characteristics defined by the researchers to add knowledge to the area being investigated. These analyzes consist of identifying characteristics of the researchers' topic of interest, among the articles, and counting the occurrence of such characteristics, enabling the crossing

of information aimed at the construction of knowledge (Thiel, Ensslin, & Ensslin, 2017). These characteristics can be basic or advanced.

The basic characteristics are those identified directly in the text and do not need to be interpreted. The basic characteristics investigated are (i) authors with research experience in the area of knowledge; (ii) countries where the studies were carried out; (iii) the economic sector of the companies; and (iv) the use of data science.

The identification of the advanced variables requires reflection and critical analysis of the content of the articles based on theoretical knowledge about the subject. It identifies the presence or not of some characteristics and analyzes them. The advanced characteristics investigated are (i) the evolution of the objectives of the safety management systems (SMS); (ii) the evolutionary movement of the OHS performance assessment areas in contrast with the performance management area, according to Bititci, Garengo, Dörfler, and Nudurupati (2012); and (iii) alignment of OHSMSs with cycle phases of a performance assessment system, as proposed by Bourne, Mills, Wilcox, Neely, and Platts (2000).

3 FINDINGS AND DISCUSSION

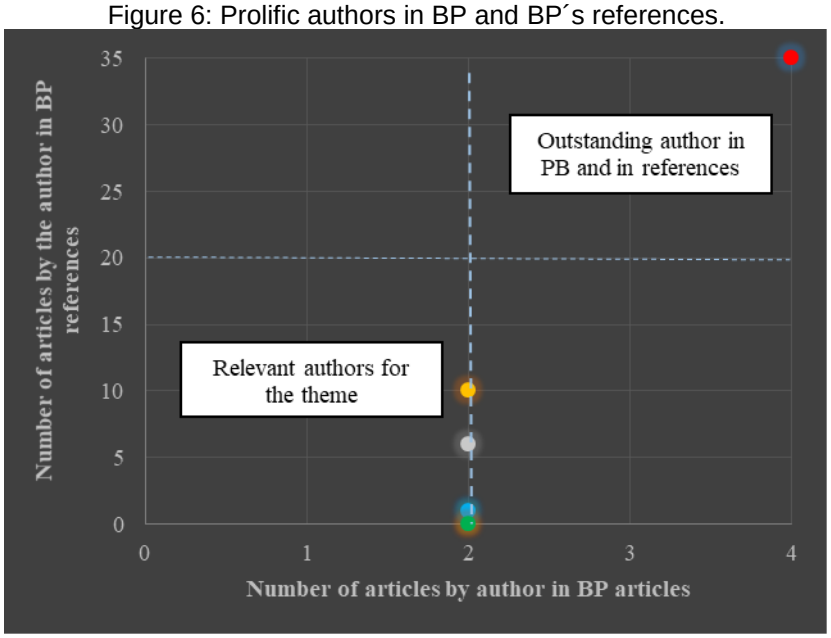
3.1 BIBLIOMETRIC ANALYSIS

3.1.1 Basic characteristics

Regarding the first basic characteristic, 98 authors were identified among the 30 articles that make up the BP. Azadeh was found to be the most prolific, with four articles. Another seven authors have two articles in the BP. 90 authors (91.8%) do not have research experience in PE in OHS or are starting to work on this topic, since they appear as one of the authors in a single paper. Among the authors with more than one citation, it was noticed that most of them had done their research in Iran, have a degree in Industrial Engineering, knowledge in Computer Science, and work with the development of mathematical algorithms.

Due to the number of articles per author in the BP references, Azadeh leads the list with 35. Figure 6 shows the analysis of cross-references (number of articles by the author in the BP and number of articles by the author in the references in the BP) to highlight the prominent authors.

Figure 6: Prolific authors in BP and BP´s references.



Colored dots represent the authors. Red: Azadeh, A.; Orange: Saberi, M.; Gray: Rouzbahma, M.; Blue: Hamidi, N.; Omidvari, M. and Meftahi M.; Green: İnan, U. H. and Valianpour, F.

Azadeh is a professor in the Department of Industrial Engineering at the University of Tehran, Iran. He works at the Center of Excellence for Intelligence based on Experimental Mechanisms. He is dedicated to research in Engineering, Computer Science, Mathematics, Decision Sciences, Business, Management and Accounting, Economics, Finance and Econometrics. His h-index was 58 and he had 13,408 citations on 02 December 2022, according to Google Scholar. He has Saberi, Rouzbahman and Valianpour as partners in two articles in the BP. Saberi is currently an assistant professor at the Center for Information, Systems and Modeling at the University of Technology Sydney. He has publications in business intelligence, data mining and the application of machine learning. He has published more than 190 articles in renowned academic journals and congresses. His h-index was 33 and he had 4,543 citations on 02 December 2022, according to Google Scholar. Azadeh, Mahsa Rouzbahman and Valianpour are his partners in this BP. It is observed that these authors are mainly specialists in mathematical modeling and, secondarily, linked to OHS. As statisticians, these authors carry out work in a wide variety of areas. Given the above, the problem arises of not having identified prolific authors who are specialists in the area of OHS.

Regarding the second basic characteristic, among the countries where the studies were developed, Iran stands out in seven articles, all of them empirical studies; followed by the United States of America (USA), in three empirical and

one theoretical; Turkey, in two empirical and one theoretical study. Iran is a developing country where the oil industry plays a key role in its economy. According to Azadeh et al. (2014), in developing countries, the existence of uncertainty and complexity is inevitable due to social, economic, and political issues. Usually, accessing accurate data due to the lack of data management systems, especially in developing countries is limited and this fact restricts the successful application of experimental methods (Asadzadeh et al., 2013). According to Shikdar and Sawaqed (2003), improving worker productivity and OHS are the main concerns of the industry, especially in developing countries.

Regarding the economic sector of companies (Table 1), the metallurgical industry is present in four articles, oil companies in three and mining, packaging and construction in two articles. The other types of companies were in only one article.

Table 1: The economic sector of the companies.

Types of Companies	**Quantity**
Metal	4
Petroleum	3
Mining	2
Packaging	2
Construction	2
Refractory	1
Cement	1
Power plant manufacturer	1
Gas refinery	1
Nuclear energy	1
Plastic	1
Gas transmission	1
Automotive	1
Electronics	1
Drilling	1
Paper	1
Aviation	1
Chemical	1
Shock absorber supplier	1
Slaughterhouse	1
Services sectors	1
Food	1

Source: Elaborated by the authors.

The reasons found for carrying out studies in those sectors are that they are complex companies, with lots of workers, high levels of absences and accidents, and financial relevance, hence, these companies aim at OHSMSs to identify and

improve their indicators. PE of Health, Safety, and Environment in large petroleum corporations is an indispensable way of strengthening safety management and promoting continuous improvement (Yan, Zhang, Liang, Li, & Du, 2017). Cement production factories are considered one of the biggest and the most dangerous companies in Iran (Hamidi, Omidvari, & Meftahi, 2012). Some jobs in the workshops such as mechanical processing, painting and maintenance are performed in unpleasant working conditions (Kahya, 2007).

While analyzing the first basic characteristics predefined by the authors, it was notable that data science and machine learning methods have been used on OHSMs. It was decided to take this feature into account. Among the 21 empirical articles, 9 made use of some data science or machine learning method. In the current competitive environment, the global economy is volatile with fluctuating demands, reflecting changing customer requirements and global economic conditions (Nudurupati, Garengo, & Bititci, 2021). To cope with the challenges brought by the increasingly competitive market, higher customer demand, and more complex risk management and control, many industries must use big data technology effectively to process and analyze massive data (Niesen, Houy, Fettke, & Loos, 2016). The decisions which can be made by statistical analysis are usually involved a few decision steps; but by machine learning (ML) methods, complex decisions more similar to that of the human brain can be made (Pishgar et al., 2021). ML is the most prevalent artificial intelligence method in use today and is employed in internet searches, e-commerce sites, goods and services recommender systems, image and speech recognition, sensor technologies, robotic devices, and cognitive decision support systems (Tamers et al., 2020). As can be seen, data science is already a reality and it is playing an important role in OHSMS. Its use was found in many papers analyzed in this study.

3.1.2 Advanced Characteristics

The analyzes were guided by two aspects: (i) the evolution of the objectives of the OHSMS and (ii) the OHS evolutionary movement in parallel to Bititci's development of the PE field.

The objectives of safety management systems (SMS) have evolved (Table 2) since the introduction of the concept, in 1973, by Kysor cited by Li and

Guldenmund (2018). Initially, the vision was purely to achieve the desired levels of safety and risk in numerical and financial terms. The techniques were developed by specialists in the area of OHS and were limited to this sector. In the 1990s, the term management was included in the definition of Carrier apud (Li & Guldenmund, 2018). This demonstrates that the systems started to include management in addition to techniques merely from the OHS field. In 1999, the term performance is inserted to evaluate safety systems as defined by the International Atomic Energy Agency. The same agency mentions the term safety culture, demonstrating a wider scope of objectives. In 2003, Ivan et al cited by Li and Guldenmund (2018) brings decision-makers into context, stating that assisting them to select strategies to improve efficiency and safety is a function of the SMS. In 2007, the International Civil Aviation Organization (ICAO) makes it clear that SMS must permeate various sectors of companies, concluding that managing safety includes the necessary organizational structures, accounting, policies and procedures. In 2009, Waddington et al. apud Li and Guldenmund (2018) mention the need to integrate management processes with the culture of safety and risk assessment, showing that the SMS is interconnected to other systems. The valuation of consumers is consolidated by HSU et al., in 2010 apud Li and Guldenmund (2018). Finally, in 2011, the objective is to distribute responsibilities to employees, making systems more self-regulatory where immediate actions are needed.

Table 2: The Evolution of the Safety Management System Objectives

	Author	**Objective**
1973	Kysor	Achieve the desired safety level or risk level.
1993	Carrier	Provide positive management control.
1999	IAEA	Promote safety culture and achieve good safety performance.
2003	Ivan et al.	Assist decision-makers in selecting effective strategies.
2007	ICAO	Manage safety, including the necessary organizational structures, accountabilities, policies and procedures.
2009	Waddington et al.	Integrate management process, safety culture and operational risk assessment.
2010	Hsu et al.	Improve product quality to meet consumer requirements.
2011	Thomas	Discharge responsibilities under the new age of the delegated responsibility of self-regulation.

Source: Adapted from Li and Guldenmund (2018).

The initial milestone and the evolution of OHS can be observed (Figure 6). Before the existence of legislation for workers, accidents were not the object of analysis, as they did not incur costs for employers. In other words, productivity was

not affected by accidents since they did not put a burden on employers due to legal helplessness. This characteristic coincides with the first period of the evolution of the performance measurement field, described as productivity management by Bititci et al. (2012).

The second period, according to Bititci et al. (2012), is called budget control. It highlights the workforce as an advantage of this age. The same aspect is noted in OHS. Since 1919, with the creation of the *International Labor Organization* (ILO) and laws to protect workers' rights, accidents started to be taken into consideration and safety measures started to be adopted. Driven by insurance companies and different industries, studies related to theories and models to understand accidents emerged highlighted by the works of Heinrich in 1931 cited by (Li & Guldenmund, 2018). Heinrich considered thousands of cases and concluded that management grossly underestimated the cost of injuries on the job (Mearns & Håvold, 2003). It was proven that accidents represent financial losses and that it was important to value workers' safety.

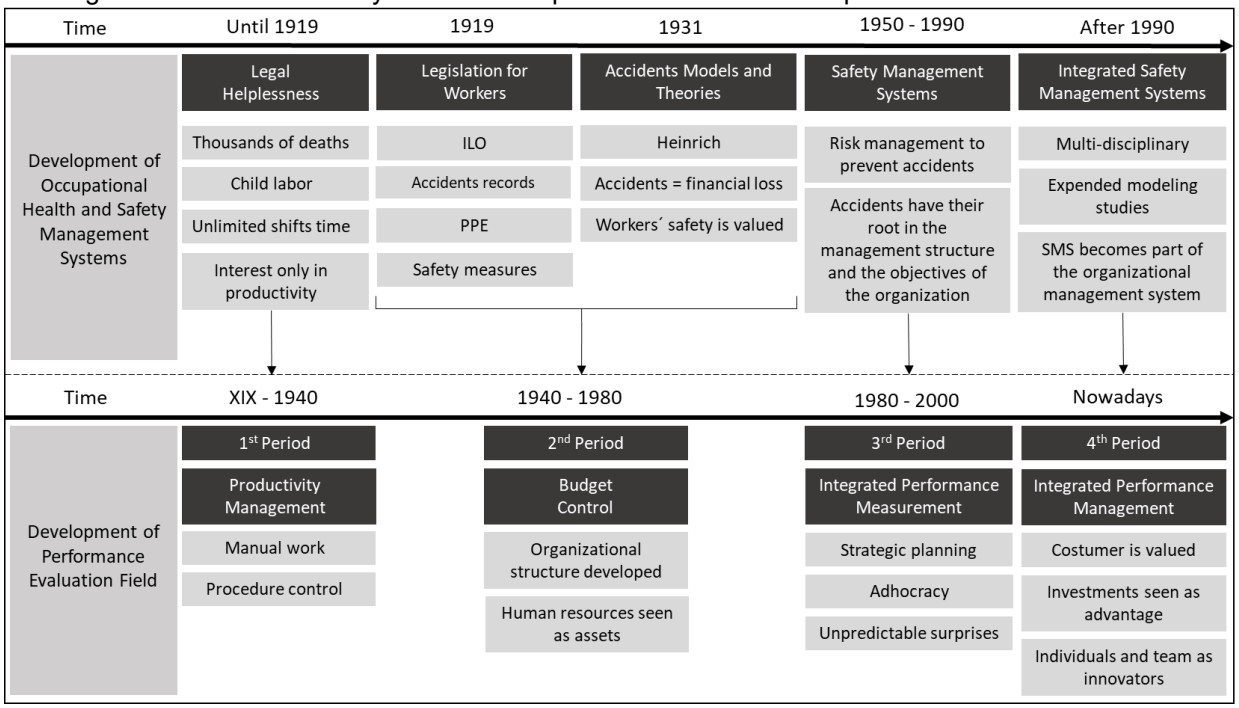
Integrated performance measurement, according to Bititci et al. (2012) is the third period and happened between 1980 and 2000. This movement can be seen in OHS as well. Companies that have more than one management system will benefit by integrating their systems into one integrated management system, where OHS and any sector are fully harmonized, and work in association with the HR, business planning, procurement, finance, operations, administration and other systems (Sadegh Amalnick & Zarrin, 2017). Integrated SMS is established to systematically integrate safety into management and work practices at all levels of the organization (Azadeh et al., 2015). One characteristic of this moment is strategic planning. In Rahimi (1995)'s study, a strategic safety management concept is proposed. To minimize health hazards, it is necessary to have an OHS policy authorized by the organization's top management that states overall OHS objectives and demonstrates a commitment to improving OHS performance (Beriha et al., 2011).

During this third period, despite their specificities, the SMSs have evolved into the fourth period of the evolution in 2000, called integrated performance management. Concomitantly, after the 1990s, SMSs became more sophisticated and multi-disciplinary by making use of an increasing number of new techniques,

audit tools, and standards. According to Li and Guldenmund (2018), they evolved from individual management systems into integrated management systems as safety management is an organizational issue. In this period, according to Bititci et al. (2012), consumers are valued. Rahimi (1995) already mentions that increasingly, internal customers (e.g. workers) require work environments that are safe, healthy, and environmentally benign, and external customers require products and services that are safe and present no negative environmental consequences.

According to Bititci et al. (2012) investment in management systems becomes an advantage during this period. The same can be seen in the OHS field. Regarding the advantage of investments, industrial safety and occupational health concerns are not only important from a government regulation point of view but also essential for enhancing productivity and profitability to become competitive in the marketplace (Beriha et al., 2011).

Figure 6: OHS evolutionary movement in parallel to Bititci's development of the PE field.



Source: Elaborated by the authors.

The third advanced characteristic shows the alignment of OHSMSs with the phases in developing a performance measurement system, as proposed by Bourne et al. (2000): (i) system design; (ii) implementation of measures; (iii) use of

measures to assess the implementation strategy; and (iv) use of measures to challenge strategic assumptions. Bourne et al. (2000) show the importance of reviewing targets, reviewing measures and challenging strategies since the environment and the organization are in constant motion. This review has been taking place in OHS performance management, as observed in the BP articles. A sound health and safety environment management should establish and maintain a process to periodically monitor and audit the key characteristics of company operations and activities that can have significant impacts on people's health, workplace safety, and the surrounding environment (Beriha et al., 2011). Based on Deming's continuous improvement cycle; the health, safety, and environment management systems are the acclaimed systems that not only would significantly minimize the risks to the enterprise, human, natural, and capital resources; but also could boost their performances through continuous learning from the past experiences and effective benchmarking of their rivals (Azadeh et al., 2012). OHSPE standards necessitate staying up to date. When the goals are succeeded, new goals and new plans should be formulated for continuous improvement to provide a sustainable OHS management comprehension (İnan et al., 2017). OHSMSs are distinguishable from traditional OHS programs by being more proactive, better internally integrated, and incorporating elements of evaluation and continuous improvement (Robson et al., 2007). Modern principles for the management of safety and the environment are closely linked to principles of quality management (ISO-9001, 2000). The main principles are the ‘‘Deming" cycle of ‘‘Plan-Do-Check-Act" (PDCA) and the concept of continuous improvement (Duijm, Fiévez, Gerbec, Hauptmanns, & Konstandinidou, 2008). It is, therefore, indispensable for a business to evaluate its OHS performance periodically (Tremblay & Badri, 2018).

3.2 LITERATURE MAP

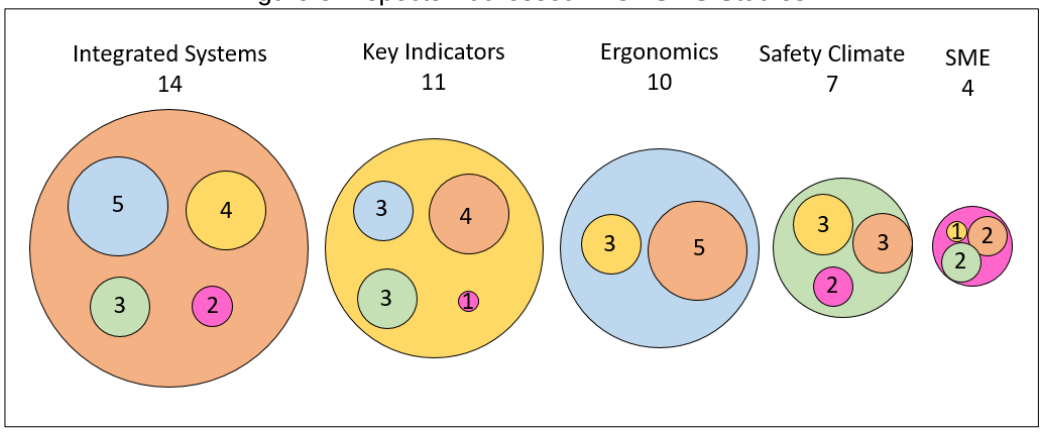
Based on the knowledge gained by reading and reflecting on the BP studies, some relevant aspects related to OHSMSs identified are integration, key performance indicators, ergonomics, security climate or culture, and small and medium enterprises (SMEs). Based on them, the literature map of the aspects emphasized by the authors on OHSMSs was created (Figure 8).

Figure 8 shows, through the diameter of the circles, the number of studies that mention the respective aspects. Within the same aspect (circle), it is possible to visualize the others that are mentioned concurrently. Thus, with the image, it is possible to identify the frequency of the themes. The integration of systems is the most mentioned topic by the authors, followed by key indicators, ergonomics, safety climate, and SMEs.

With this mapping, it is possible to affirm that integrated OHSMSs, mainly with the inclusion of ergonomic aspects, is a relevant topic and has encouraged and resulted in a wide range of studies. Its importance can arouse interest in new researches. However, the amount of knowledge already generated by previous studies can make it difficult to generate new expertise.

On the other extreme, the share of studies involving SMEs can be considered poor. Only 5 articles were developed in SMEs. Furthermore, no article from the BP included ergonomics aspects in SMEs. This finding demonstrates a gap with potential to be explored enforced by the importance that large corporations have devoted to comprising ergonomics in the OHSMSs.

Figure 8: Aspects Addressed in OHSMS Studies



Source: Elaborated by the authors.

4 CONCLUSIONS

Based on the analysis and results some conclusions can be drawn. There is a lack of authors whose base of knowledge is related to safety engineering. The interest of safety engineers in developing scientific studies may contribute to enhancing the OHSMS field together with professionals from other areas.

The safety management system objectives and the OHS evolutionary

movement analyzed in parallel to Bititci's development of the PE field have evolved and will keep on developing and adapting to the dynamic change of the environment reaching broader aspects as safety should be present in any sector and levels of the corporations. Therefore, the continuous improvement and PDCA approach tend to continue to play an important role.

Even though ergonomics was not part of the keywords, it is becoming part of the OHSMSs in several studies. Therefore, developing ergonomic indicators to be used in performance evaluation proves to be a promising field for future studies.

The use of data science, artificial intelligence (AI) and machine learning in OHSMSs have grown a lot and quickly and have contributed to the evolution of the area. ANNs are the most used models. There is a high probability that the use of machine learning, based on big data and AI will be found in most management systems soon.

Another point that may contribute to the development of OHSMSs is longitudinal studies. This kind of research related to the maturity of management systems remains rare. This type of research can bring fertile contributions to the area, as its merits in general performance management have already been noted.

This research was limited to articles published in English, in scientific journals, and articles found by the keywords in the titles, abstracts, and keywords in the databases *Scopus* and *Web of Science*. Thus, searching for studies in other languages, books, and publications in congresses and/or other databases will increase the scope of the search. However, this would not necessarily imply a quality improvement.

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