R. Ação Ergon., 15(2), 2021.
ISSN 2965-7318. doi: 10.4322/rae.v15n2.e202108.en

ERGONOMICS IN THE OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

Carmen Elena Martinez Riascos [1]*

Leila Amaral Gontijo [2]

Eugenio Andrés Díaz Merino [3]

Abstract

The Occupational Health and Safety Management System (OHSMS) seeks to identify and assess occupational risks and meet the legal requirements of each economic sector. Ergonomics, in turn, is also related to the protection of workers' health, establishing a close relationship in its domains of specialization (physical, cognitive and organizational). In this sense, this article aims to characterize the articles that address Ergonomics and the Occupational Health and Safety Management System (OHSMS) and identify which domains of ergonomics were used. This qualitative research chose the Knowledge Development Process-Constructivist (ProKnow-C) instrument for the selection of literature, identification, analysis and reflection of the characteristics of OHSMS. Thirty-one articles were selected as the fragment of scientific literature, performing an advanced bibliometric analysis, identifying characteristics of the methodological approach and the techniques used for data collection. The list of methods or tools analyzed or used is presented and the aspects of the domains of physical, cognitive and organizational ergonomics considered by the researchers in their studies were identified. It was identified that cognitive ergonomics is being addressed from activities and training, and the evaluation of worker performance and stress control are beginning to be worked on. Regarding organizational aspects, the incursion of organizational culture in companies has contributed to working on the management of prevention activities with workers.

Keywords: Ergonomics; Occupational Health and Safety; ProKnow-C..

1. Introduction

Ergonomics seeks to adapt work to human beings, covering not only the activities carried out with machines and equipment used to transform materials. It involves the whole relationship between the person and productive activity. This involves, in addition to the physical environment, psychological and organizational aspects. Therefore, in order to achieve the desired results of the work, both planning and design activities and control and evaluation activities must include ergonomics with its physical, cognitive and organizational domains in order to obtain a complete management system (Iida & Buarque, 2016).

[1] Federal University of Santa Catarina – UFSC. * carmen.elena@posgrad.ufsc.br.
[2] Federal University of Santa Catarina – UFSC.
[3] Federal University of Santa Catarina – UFSC.

The *International Ergonomics Association* (IEA) defines ergonomics as the scientific study of the relationship between human beings and their environments, methods and workplaces. Its objective is to develop, through the contribution of the various scientific disciplines that constitute a body of knowledge that, from an application perspective, should result in order to obtain a better adaptation of technological means, work and living environments. Ergonomics considers the domains of physical, cognitive, and organizational specialization to achieve a holistic approach (IEA, 2019).

Physical ergonomics studies the characteristics related to the physical activities performed by people, taking into account approaches to human anatomy, anthropometry, physiology, and biomechanics. Cognitive ergonomics related to people's interaction with the environment, such as perception, memory, reasoning, and motor response. Finally, organizational ergonomics deals with aspects related to sociotechnical systems, addressing organizational structures, policies, and processes (IEA, 2019).

To solve problems related to health, safety, comfort and efficiency, it is necessary to use the fields of ergonomics. The ergonomic approach is based on systems theory, analyzing the relationship between the worker and his or her tasks. Thus, risks can be controlled or reduced, considering human capabilities and limitations during the project and its environment. This approach can also help prevent errors and improve employee performance. It brings numerous benefits both from a financial point of view to reduce costs and to increase productivity, from a motivational point of view.

In the same way, obtaining safe work areas, ensuring the physical, psychological and social health of their employees is a constant concern of organizations. To achieve these objectives, the Occupational Health and Safety Management System (OSHMS) was developed. The primary purpose of an OHSMS is to control losses, accidents, hazards, and risks. The organization must identify what it should monitor and how to carry out this control. In turn, the Occupational Health and Safety Management System is considered a set of policies, strategies, practices, procedures, activities, and functions related to safety (ISO, 2018; Kirwan, 1998; Mearns et al., 2003).

The OHSMS should be designed and implemented considering that, when exposed to occupational risks, it is necessary to analyze the physical, biological, cognitive, mental and social dimensions. In addition, it includes individual variability, both inter- and intra-individual (Garrigou et al., 2007). A work situation, from the ergonomic point of view, is a complex, dynamically interrelated one, whose inputs (technical, environmental and labor tasks) determine human behavior at work (activities in terms of information and actions) and production (work results in terms of production and health), are the result of this system (Iida & Buarque, 2016).

However, the OHSMS looks at people, technology, and the work environment separately. And, ergonomics proposes a systemic approach to aspects of human activity in the contribution of the scientific disciplines that shape it, resulting in a better adaptation to the work environments and environments (IEA, 2019). The application of ergonomics can improve worker productivity, occupational health, safety, and satisfaction. Providing support to achieve the organization's goals (Shikdar & Sawaqed, 2004).

Safety ergonomics analyzes the factors that influence people and their behavior in any working condition and critical safety issues (Abu-Khader, 2004; Lima et al., 2015; Vogt et al., 2010). These safety assessments should incorporate sources of risk for humans and for organizations working on daily analyses and quantify them in a very realistic way (Colombo & Demichela, 2008).

Ergonomics goals are related to protecting workers' health, from reducing exposure to physical and cognitive overload, among other harms. The main objective is to improve, first of all, the comfort of the worker, as well as their health, safety and efficiency. In this way, the application of ergonomic principles generates benefits for both the employee and the employer and can contribute to the continuous improvement of the organization. It is estimated that healthy employees can be almost three times more productive than those with health problems (Niu, 2010). In the field of occupational safety, it has stood out for the promotion of continuous improvement.

Ergonomics in OSHMS involves not only technical issues of occupational safety, but also issues related to human behavior in general (Maggi & Tersac, 2004). It is mainly associated with the well-being of workers, most often coordinated from the Department of Safety and Health (DST). This is why managers tend to inadvertently restrict their scope of intervention to the dangers of physical ergonomics, rather than benefiting from its help for organizational effectiveness, business performance, or costs (Nunes, 2015). In identifying risks, it is necessary to understand not only the physical characteristics of the activity, but also the cognitive and organizational aspects and take them into account in the development of safety systems. Involving questions about commitment, learning, motivation and others are essential in the risk analysis process, as expressed in the contemporary view that addresses the theme of occupational safety (Maggi & Tersac, 2004).

This article aims to characterize the researchers' approach and identify which domains of ergonomics are used in the Occupational Health and Safety Management System (OSHMS). Therefore, the *Knowledge Development Process-Constructivist* (ProKnow-C) (Dutra et al., 2015; L Ensslin et al., 2017; S. R. Ensslin et al., 2014) was used as a tool to select the articles and develop an analysis that allowed us to survey the research associating Ergonomics and OSHMS.

2. Method

This section is divided into (i) Methodological structure; (ii) Intervention instrument; (iii) Portfolio selection process and data collection; (iv) Procedures for data analysis: advanced bibliometric analysis and research opportunities.

2.1. Methodological structure

This research used a qualitative-quantitative method (Creswell, 2014) to analyze the problem and the objective. As well as a bibliographic approach and action research parameters with the Knowledge *Development Process-Constructivist* (ProKnow-C) instrument.

The choice of the methodological process in this scientific research is related to the problem being researched (De Oliveira Lacerda et al., 2014). This is an exploratory research that describes the characteristics of the articles of a fragment of scientific literature, through an action research, defining the limits to choose the articles identified as relevant to analyze Ergonomics and the OSHMS. Action research refers to an evaluative, investigative, and analytical research method aimed at diagnosing problems, i.e., constructivist (Creswell, 2014).

Based on the research constraints, the Bibliographic Portfolio (BP) is defined to be analyzed to identify the knowledge bases for Ergonomics and Occupational Health and Safety Management System. Primary and secondary data are used in data collection. The selection of the portfolio uses primary data, since the restrictions are carried out by the researchers during the selection process. Bibliometric analyses, on the other hand, use secondary data, since the information is extracted from the articles. Thus, the presence of subjectivity is intrinsic to this process.

2.2. Intervention instrument - ProKnow-C

The tool adopted to achieve the results of this research was developed by LabMCDA of the Federal University of Santa Catarina, Brazil, which is called *Knowledge Development*

Process-Constructivist (ProKnow-C) (Dutra et al., 2015; Leonardo Ensslin et al., 2012; S. R. Ensslin et al., 2014). This instrument is developed in four stages: (1) selection of the bibliographic portfolio; (2) bibliometric analysis; (3) systemic analysis and (4) formulation of research questions and objectives (Cardoso et al., 2015; Dutra et al., 2015; Valmorbida et al., 2016; Valmorbida & Ensslin, 2015).

To select the bibliographic portfolio at each stage, some activities are carried out. In stage 1, according to the researchers' perception, a limited set of relevant scientific articles aligned with the research theme are identified. In step 2, it presents the most relevant articles, authors, journals, and keywords in BP. In step 3, the systemic analysis of the BP characteristics is performed. In step 4, researchers can define the research question and objectives (Cardoso et al., 2015; Dutra et al., 2015; L Ensslin et al., 2017; Valmorbida et al., 2016; Valmorbida & Ensslin, 2015). The article presents, as a delimitation, the development of stages 1, 3 and 4.

2.3. Process for portfolio selection and data collection

This process is identified as Gross Database (BAB) selection and involves: (i) definition of keywords; (ii) selection of databases; (iii) search for articles in databases selected from the defined keywords; and, (iv) keyword adherence (Cardoso et al., 2015; Dutra et al., 2015; L Ensslin et al., 2017; Valmorbida et al., 2016; Valmorbida & Ensslin, 2015). The limits of the process were defined: (i) articles published in scientific journals; (ii) articles published since 1997; (iii) search in the title, abstract, and keywords of the articles; and, (iv) articles published in English and Portuguese. Access to the databases was carried out through the network of the Federal University of Santa Catarina (UFSC). It is used as a support for the EndNote® X9 software (Thomson Corporation, 2018) to manage the databases used in the search process.

Filtering starts by excluding non-aligned articles, conference papers, or books. Then the duplicate items are deleted. The next step is the; selection by alignment of the title with the theme, then those with an aligned abstract were selected. Finally, a complete review of their content was carried out to define which will be called Bibliographic Portfolio (BP).

The last part of the selection of articles corresponds to the Representativeness Test. In it, the selection of articles from BP references is made. The filtering process is carried out using the same criteria: aligned by title, scientific relevance, selection of relevant and recent authors written by renowned authors, review of the abstract. Once selected by an aligned abstract, these works are read completely, verifying which ones are aligned with the research theme. The selection process of the Bibliographic Portfolio, including the representativeness test, are illustrated in the flowchart in Fig. 1.

Thus, the stage of the selection process of the Bibliographic Portfolio is concluded, and then the content analysis stage begins.

2.4. Procedures for data analysis

Advanced bibliometric analysis and research opportunities aims to generate knowledge for researchers about certain characteristics of the topic under investigation. This bibliometric analysis identifies and highlights specific variables/basic characteristics, in the BP articles and their references (Dutra et al., 2015; L Ensslin et al., 2017; S. R. Ensslin et al., 2014; Valmorbida et al., 2016). From the knowledge of this information, the researcher can then collect additional data on the subject, as he makes inferences and subsidizes his choices.

In this research, we present the variables that allow us to expand the knowledge of the theme: (i) type of methodological approach to the research; (ii) nature of the methodological approach; (iii) scope of the study; (iv) unit of analysis; (v) data collection techniques; and, (vi) tools used in empirical studies.

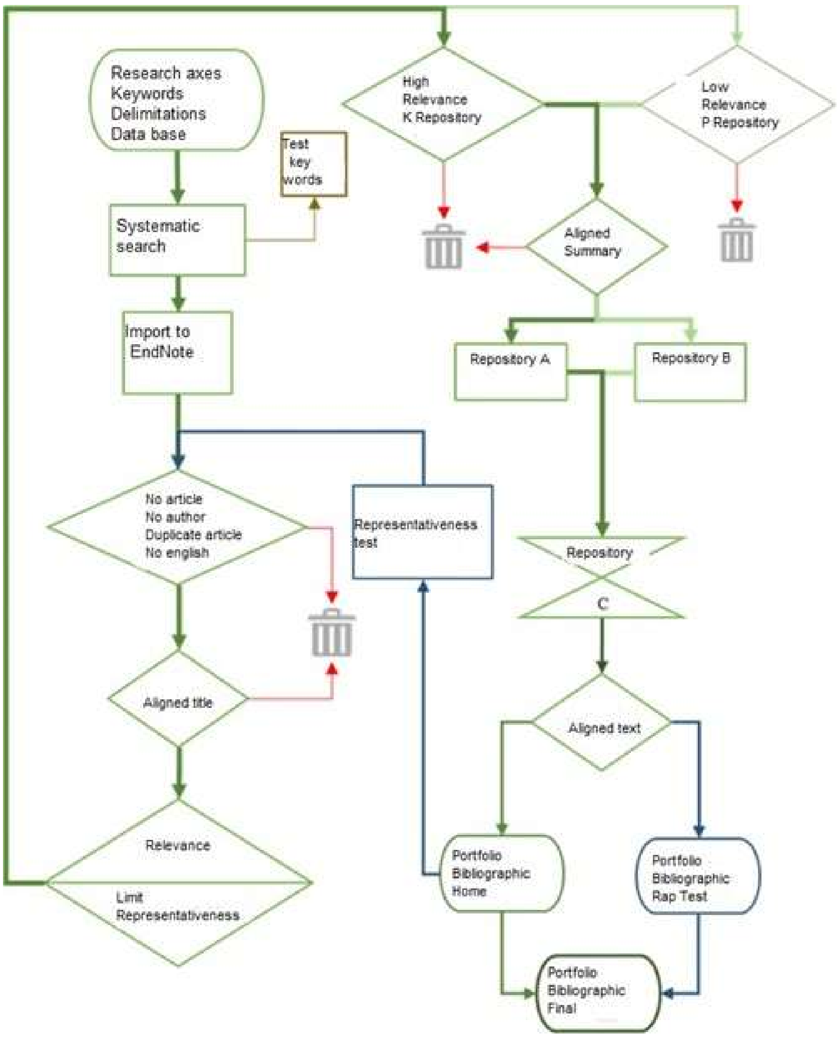

Figure 1. Portfolio selection process

3. Results and considerations

The consultation in the databases resulted in 11602 documents, after applying the ProKnow-C selection process, presented in Fig. 1, 31 articles were selected.

According to the selection and delimitation criteria applied by the researchers, it was considered that they address the theme of Ergonomics and the Occupational Health and Safety System.

Parameters were defined to analyze the characteristics of the selected articles. This article presents the advanced variables that allow generating information about the research carried out. In order to know the stage of evolution of the theme, the variables considered relevant to the characteristics of the analyzed research are presented. The research design includes the interrelated elements that reflect its sequential nature and contribute to explaining the results. Researchers must decide on the links between the research steps and the purpose of their study and the approach and methods of the research. The variables, described below, offer knowledge of the pillars of the BP fragment, contributing to the choice of new research.

3.1. Advanced variables

The following analyses are presented: methodological approach, nature of the methodological approach, scope of the study, unit of analysis, and the techniques used for data collection. The list of methods or tools analyzed or used in the selected articles is presented. Finally, the aspects of the domains of physical, cognitive and organizational ergonomics considered by the researchers in their studies are highlighted.

The first characteristic identified was the type of methodological approach to the research. This approach refers to identifying how the various ways of approaching or treating reality are identified, related to different conceptions of this reality. The methodological approach was classified as: modeling, theoretical-conceptual, literature review, simulation, *survey*, case study, action research and experiment. The amount of each type of approach is illustrated in Fig. 2. Reviews of the scientific literature were conducted on most of the articles, but case studies were used to present the research results.

In 8 articles, the researchers used the combination of several types of methodological approach. For example, in the article "*Using leading indicators to measure occupational health and safety performance*" was a case study with action research and simulation (Sinelnikov et al., 2015).

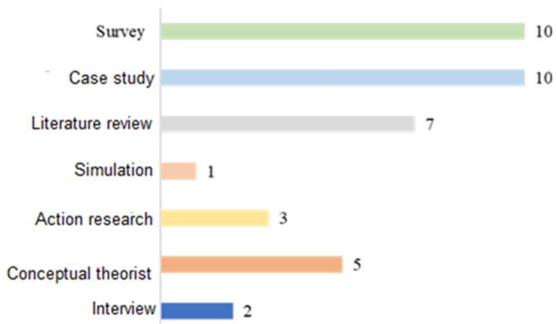

Figure 2. Methodological approach to the research

As for the nature of the approach, it was sought to identify whether it was qualitative, quantitative, descriptive and predictive. It was possible to identify that 14 articles performed a qualitative description of the results. In the other 17 cases, a combination of quantitative and qualitative research techniques was used by the authors in order to increase the validity of the results.

It was also identified where the implementation of the results of the articles could be, taking into account the scope of information on which the authors were based. The scope of the study's information was classified as: company, economic sector, region (2 or more cities), national and international (Fig. 3).

In 10 of these studies, international information was used, without applying concepts of laws or norms of any country or economic sector in particular, and in 10 of the articles, the information was based on specific data from a company, 9 articles analyzed national data and 2 regional data.

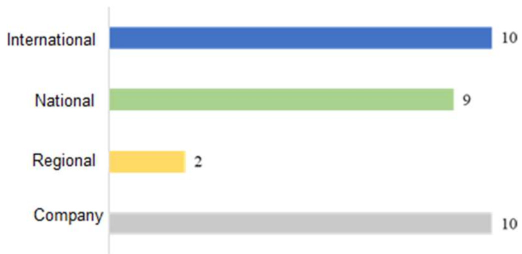

Figure 3. Scope of study information

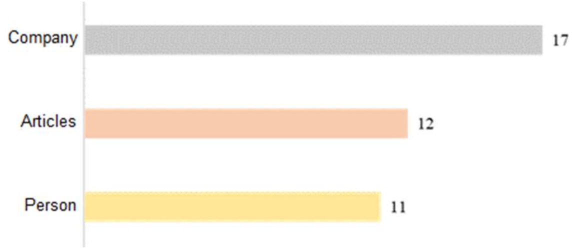

Figure 4. Origin of information

The following analysis follows the origin of the information. The articles were classified according to the unit of analysis used by the researchers, namely: people, articles, products, organizational unit and companies. It was possible to identify that 17 were based on internal documents and company data, 12 based their results on the analysis of published scientific literature, 11 correspond to questionnaires or interviews with people. Data shown in Fig. 4.

Likewise, the collection techniques were identified, which were classified as a questionnaire, interview, company document, observation and public document. To perform data collection, in 2 of the articles, observations were made in the workplaces or at people's work. 5 had interviews and 14 had questionnaires. In 25 of the investigations, the authors used company documents and 3 public documents, Information presented in Fig. 5.

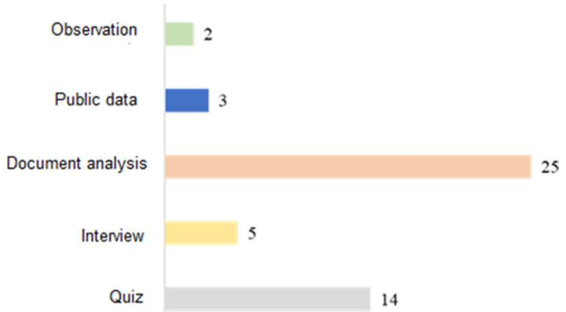

Figure 5. Data collection techniques

An important topic for researchers is to identify which methods and tools were used in the studies. In the articles analyzed, it was possible to identify several tools, some fully implemented and others with adaptations. The list of tools or methods used or analyzed in the articles of the portfolio is presented in table 1. Some are used in the information collection process, such as *Safety climate survey* (Payne et al., 2010) and *Process hazard analysis (PHA)* (Kariuki & Löwe, 2007). Others to perform statistical analysis such as *Regression analysis (management-by-exception active; MBEA)* (Molnar et al., 2019) and *T-test* (González et al., 2003). Likewise, OHSMS assessment methods such as the *Safety Element Method (SEM), Universal Assessment Instrument (UAI), Safety Diagnosis Criteria (SDC), Occupational Health and Safety Self-Diagnostic Tool (OHSSDT), The pyramid of chemical major accident prevention (PYRAMAP)* (Sgourou et al., 2010).

In the same table 1, information was recorded on which aspects of the ergonomics domains were mentioned by the authors. Throughout the analysis of each article in the portfolio, it was identified which parts of physical, cognitive, and organizational ergonomics were considered by the authors in the development of the research. Articles focused on organizational climate, for example, emphasize aspects of organizational ergonomics and may not include aspects of the other domains (Hoffmeister et al., 2015; Payne et al., 2010). Likewise, we identified that a group of researchers used macroergonomics (domain of organizational specialization) in the implementation of the OHSMS, using the *MacroErgonomic Analysis and Design method (MEAD) and Macroergonomic Analysis of Structure (MAS*) as work tools (Haro & Kleiner, 2008).

The advanced analysis allowed us to know the characteristics of the ergonomics and OHSMS articles. It was identified that ergonomics is used more frequently to analyze the physical aspects of the worker's risk. However, it is practically not used by applying the domains of expertise (physical, cognitive, and organizational) in a comprehensive way as part of OSHMS. The opportunity was identified to continue the research with the construction of models oriented to implement or evaluate the OHSMS, using the domains of specialization of ergonomics to improve risk control in occupational activities.

Ergonomics is a necessary and integral part of the activity that health and safety considers, seeking to adapt the operating and commercial conditions of work to the needs and capabilities of the human being, instead of requiring him to adapt to the work environment. It considers human well-being and the overall performance of the system (Radjiyev et al., 2015).

4. Discussion

The objective of this study was to examine the articles on Ergonomics and the Occupational Health and Safety Management System. We had two general objectives: to examine some features of the researchers' approach and to determine which domains of ergonomics were present in the OSHMS.

With the process of analysis of the selected articles, it was possible to observe that ergonomics is not approached with a holistic view, but rather a punctual one. Aspects of organizational ergonomics are being addressed by specialists and researchers are advancing in criteria for implementing this domain (Haro & Kleiner, 2008; Hoffmeister et al., 2015; Payne et al., 2010). In six articles, the SGSST was the theme of aspects related to the training of workers (Asadzadeh et al., 2013; Boatca & Cirjaliu, 2015; Givehchi et al., 2017; Hoffmeister et al., 2015; Nwankwo et al., 2020; Tamim et al., 2019) and in two those related to the stress generated by occupational activities (Eskandari et al., 2021; Niu, 2010), both are part of the aspects of cognitive ergonomics. This shows that aspects of cognitive and organizational ergonomics are beginning to be worked on in organizations.

This study has some limitations. Firstly, although more than 5,095 ergonomics articles and more than 6,507 OHSMS articles have been selected for classification, we cannot exhaust all related publications due to the interdisciplinary nature of ergonomics and OSHMS. Secondly, the classification of an article depends not only on the professional knowledge of each reviewer, but also on their personal judgments of substantial contribution to each category, so subjectivity is inevitable in this classification process. More rigorous criteria in the classification of articles should be further studied. In addition, most of the areas identified for the contribution of ergonomics to OSHMS should be considered only as somewhat mature areas of contribution, they are not necessarily the most promising areas of research, since the most promising areas may be those that are not yet popular.

R. Ação Ergon., 15(2), 2021.
ISSN 2965-7318. doi: 10.4322/rae.v15n2.e202108.en

Table 1. Methods or tools used and Domains of ergonomics.

Method/tools analyzed or used	Physical Ergonomics	Organizational Ergonomics	Cognitive Ergonomics	Authors	Year
Safety climate survey		Organizational climate, process in audits, self-assessments and inspections, defined systems and processes	autonomy for decision-making, Assessing safety risks before doing a job	Payne, S. C., Bergman, M. E., Rodríguez, J. M., Beus, J. M., Henning, J. B.	2010
Qualitative Comparative Analysis (QCA)		Organizational Complexity, Contract Management, OHS Planning, Project Management, Management Commitment, Safety Climate, Operational Risk Management, Site Management, Personnel Management	Roles and responsibilities, Learning, Performance appraisal	Winge, S., Albrechtsen, E., Arnesen, J.	2019
Statistical Analysis (The mean and standard deviations). F-test	Improve the physical fitness of all employees associated with the reduction of cases of loss	Identify more hazardous jobs or working conditions, ergonomically speaking, using sources such as discomfort reports, worker injury and illness records, medical records, or job analyses. Improve the physical fitness of all employees associated with the reduction of cases of loss	Global approach to ergonomics in risk prevention	Wurzelbacher, S., Y. Jin	2011
Fuzzy Analytic Network Process (FANP)		Safety performance include organization, environment, and individual factors. The role of organizational factors in occupational accidents and the relationship between safety climate and safety outcomes, such as compliance with safe work practices. Organizational factors: management's commitment to safety (MC), employee participation (EP), safety communication (SC), blame culture (BC), safety training (ST), interpersonal relationships (IR), safety supervision (SS), reward system (SR) and continuous improvement (CI). Perception of safety rules and regulations (PR).	Risk taking (RT), emotional instability (EI), safety awareness (SA), job satisfaction (JS), fatigue (FA), job competence (WC), workload (WL), job stress (WS).	Eskandari, D., Gharabagh, M. J., Barkhordari A., Gharari N., Panahi D., Gholami A., Teimori-Boghsani G.	2021
Longitudinal statistical models, IBM SPSS version 25 using generalized estimating equations (GEE)		Indicators to manage occupational safety. Frequency or severity of incidents of negative safety such as property loss or injury.		Yorio, P. L., Haas, E. J., Bell, J. L., Moore, S. M., Greenawald, L. A.	2020
Production management systems, health and safety management systems)	Musculoskeletal Risk Control with the design of the equipment, the types of strenuous movements performed. Equipment design and workstation layout.	Ergonomic design of workplaces and product quality levels, production procedures		Caroly, S., Coutarel, F., Landry, A., Mary-Cheray, I.	2010
Process hazard analysis (PHA), Human reliability analysis (HRA): THERP, SLIM, cognitive reliability and error analysis method (CREAM), technique for human event analysis (ATHEANA) {nuclear industry is more mature than in the chemical process industry. HAZOP and fault tree analysis. process industries safety management, PRISM		The integration of human factors analysis into PHA to identify, understand, control and prevent human-related failures. It analyzes the factors behind the occurrence of human error.		Kariuki, S. G., Lowe, K.	2007

organizational design and management (ODAM) in ergonomics, Macroergonomic Analysis of Structure (MAS), Rapid Universal Safety and Health (RUSH) system (The RUSH system was created using sociotechnical and system safety concepts), System safety human system integration: Preliminary Analysis, Event Tree Analysis, Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), Fault Hazard Analysis, Subsystem Hazard Analysis, System Hazard Analysis, Cause–Consequence Analysis, MacroErgonomic Analysis and Design method (MEAD).		Company-documented safety information and employee perceptions (climate, culture), System environmental expectation (regulations), and system expectation of the environment (regulatory support). Participatory ergonomic interventions in the dynamics of communication in the workplace. Levels of organizational complexity, centralization and formalization.	Perceived safety role and responsibility of identified stakeholders, Provide safety training support	Haro, E., Kleiner B. M.	2008
	Adverse ergonomic working conditions can cause visual, muscular, and psychological disorders such as eye strain, headaches, fatigue, MSDs such as chronic back, neck, and shoulder pain, Cumulative Trauma Disorders (CTDs), Strain Injuries Repetitive Motion Injuries (RSIs) and Repetitive Motion Injuries (RMIs).	The organisation of work, the organisation of working time, the different working hours (daytime versus various types of shift work).	Psychological job demands, decision latitude, and social support are three key measures of psychosocial factors in the workplace that affect workers' health. Psychological tension, anxiety and depression.	Niu, S. L.	2010
Simulation of full-scale workplaces. Autoconfrontation method		Participatory methodology, participatory approach to management.		Kuorinka, I.	1997
Knowledge management (KM)			Existing individual (personal) knowledge, structural knowledge (i.e., knowledge codified in manuals, reports, databases, and data warehouses), and organizational knowledge (learning activity within the organization) in the vast domain of practical applications.	Sherehiy, B., Karwowski, W.	2006
human reliability analysis. Model for Successful Ergonomics Intervention		Ergonomic intervention, reduction of human errors, increased productivity and speed of execution.	The importance of the organizational environment from a social, physical and metal point of view. Ergonomic intervention begins and ends with training.	Boatca, M. E., Cirjaliu, B.	2015
A regression analysis was conducted to examine the relative roles of transformational, transactional (management-by-exception active; MBEA), and safety-specific leadership for different safety behavioral outcomes (compliance behavior and safety initiative behaviors) and for minor and major injuries.		Communicate safety issues and values during daily work. Security climate. Leader's behaviors.		Molnar, M. M., Schwarz, U. V. T., Hellgren, J., Hasson, H., Tafvelin, S.	2019

BME (in free translation 'Ergonomic Assessment Model'), Passive observation was used during twelve Work Environment Safety Group (WESG), participatory observation, a process where theoretical framework, empirical fieldwork and case analysis evolve simultaneously. Strategic analyses and improvement work for safety on plant level, Risk analyses and improvement work for safety on assembly plant level, Follow up and assist the work of WESG, work with strategies for ergonomics and work safety, Risk analyses, work with the BME mode, Discussions about production	Each work task is evaluated in terms of posture, strength requirements, and frequency of tasks. The final assessment is expressed in risk values.	Participatory model between the engineer and the safety representative.		Tornstrom, L., Amprazis, J., Chritstmansson, M., Eklund, J.	2008
problems and how to solve, Follow-up results of solutions, An open meeting for any suggestions or subject, Improvements of the process, Information					
Balanced scorecards (BSC) Human Resources Performance Model (HPM). Critical Incident Stress Management (CISM)		Integration of human factors in the safety management of aviation companies.		Vogt, J., Leonhardt, J., Köper, B., Pennig, S.	2010
Responsible Care Process Safety Code (RCPSC), CIMAH regulations, API RP 750, US OSHA PSM Program, Safety Case, ExxonMobil OIMS, ILO PSM Framework, API RP 75, EPA RMP, COMAH regulations, AIChE/CCPS Risk Based Process, Safety (RBPS) Model, BP OMS, SEMS Regulation, Energy Institute High-Level PSM Framework, Operational Risk Management (ORM) Model, CSChE PSM Guide 4th edition, IOGP/IPIECA OMS Framework, Process Safety Information Management System (PSI4MS), Contractor Management System (CoMS), Emergency Planning and Response (EPR) model, IPSMS model		Human factors (man, machine, process), safety culture, industry adaptability, human factors, scope of application, use in complex systems, safety culture, primary or secondary mode of application, regulatory application.	Training requirement, inductive or deductive approach.	Nwankwo, C. D., Theophilus, S. C., Arewa, A. O.	2020
Caused-based methodology		Safety-critical activities performed. Lack of process compliance. Inadequate instructions and control procedure.	Inadequate evaluation of training and competence.	Tamim, N., Laboureur, D. M., Hasan, A. R., Mannan, M. S.	2019
Project Management Body of Knowledge. Software Engineering Institute (SEI). Cal Path Method (CPM). Preliminary Hazard Analysis. Methodology for analysis of system dysfunction (MASD). Systemic structured methodology of risk analysis (MOSAR). Risk Assessment Model (RAM). PVA-Kaizen. Kaizen-blitz.	Ability, health and physical condition	Internal communication, culture, organizational approach, communication.	Worker attitudes, motivation.	Badri, A., GBODOSSOU, A. NADEAU, S.	2012

RULA - Rapid Upper Limb Assessment, REBA - Rapid Entire Body Assessment, OWAS - Ovako Working Posture Analysis System, PATH - Posture, Activity, Tools and Handling, Biomechanical or digital human modelling, Body Discomfort Map (e.g. Corlett and Bishop Map), JCQ - Job Content Questionnaire, PLIBEL, Rodgers Muscle Fatigue Analysis, Psychophysical Material Handling Data, NIOSH Lifting Equation, Energy Prediction Model, ACGIH Threshold Limit Value, Washington State (WISHA) Lifting Calculator, Ohio Bureau of Workers Compensation (BWC) - Lifting Guidelines, Health & Safety Executive (HSE) (MAC tool), Psychophysical Upper Extremity Data (e.g. "Snook and Ciriello Tables"), Strain Index, OCRA, TLV for Hand Activity (ACGIH), TLV for Upper Limb Muscle Fatigue (ACGIH), Health & Safety Executive, (HSE) Assessment of Repetitive Tasks (ART tool), Muscle fatigue equations, Lumbar Motion Monitor (LMM)/other trunk electrogoniometer, Electronic Wrist Goniometer, Grip Dynamometer, Pinch Dynamometer, Instrumented Hand Tools (for force measurement), Heart Rate Monitor, Push/Pull Force Sensors, Electromyography, Vibration Measurement, Motion capture/measurement (optical, requiring cameras), Motion capture/measurement .	Musculoskeletal assessment			Lowe, B. D., Dempsey, P. G., Jones, E. M.	2019
Model of safety culture		Safety Management and Leadership, Strategic Management, Supervisor Activity, Proactive Safety Development, Safety Management work, Work process management.	Competence management	Reiman, T., Pietikainen E.	2012
Model of workplace safety with concentric layers of the work system, socio-organisational context and the external environment. Model of a sociotechnical safety control structure in STAMP		Socio-technical system for safety at work		Carayon, P., Hancock, P., Leveson, N., Noy, I., Sznelwar, L., Van Hootegem, G.	2015
Quantitative survey		Monitor an organization's ability to safely execute procedures, safety management system for continuous improvement (e.g., safety management leadership, contingency planning).		Sinelnikov, S., Inouye, J., Kerper, S.	2015
Simple modeling of the relationship between resilience and safety	Anthropometry, physiology. Improvement of the physical environment	Optimize the socio-technical system. Organizational structures in human behavior and safety. Quality of work processes.	Cognitive psychology. Training and the satisfaction of staff members.	MOREL, G., AMALBERTI, R., CHAUVIN, C.	2009
Safety Element Method (SEM), Universal Assessment Instrument (UAI), Universal Assessment Instrument (UAI), Safety Diagnosis Criteria (SDC), Occupational Health and Safety Self-Diagnostic Tool (OHSSDT), The pyramid of chemical major accident prevention (PyraMAP)		Relationships Organizational and human factors. Interrelationships: Relations between technical, organizational and human factors, Intrarelationships: Relations of the safety management system with the organization and the external environment.		Sgourou, E., Katsakiori, P., Goutsos, S., Manatakis, E.	2010

Integrated safety management model.		Leader motivation, Leader discussion, Leader's unity/commitment, Trust in the leader, identify cooperation issues.	Leader performance, Personal conflict, Working conditions, Harassed employees, Work environment, Power struggles	Lofquist, E. A.	2010
Psychometric analysis of the Organizational Performance Metric – Monash University (OPM-MU), classical test (exploratory factor analysis) and item response (Rasch model analysis)		Responsibility for OHS, Consultation and communication on OHS, Management and leadership commitment, Positive feedback and recognition for OHS, Prioritization of OHS, Risk management, Systems for OHS (policies, procedures, practices).	Employee empowerment and involvement in OHS decision-making	Shea, T., De Cieri, H., Donohue, R., Cooper, B., Sheehan, C.	2016
Machine learning (ML) approaches, Boruta feature selection technique and decision tree.				Poh, C. Q., Ubeynarayana, C. U., Goh, Y. M.	2018
Multilevel modeling		Formal OHS audits. Continuous improvement of OHS. Workers and supervisors have the information they need to work with safety. Positive recognition. Resources or equipment to get the job done safely.	Employees are always involved in decisions that affect their health and safety. OHS managers have authority to make the changes they identified as necessary.	Sheehan, C., Donohue, R., Shea, T., Cooper, B., De Cieri, H.	2016
Ergonomics Climate Assessment	Workstation project	Employee Wellbeing, Communication, Employee Involvement. Monitoring the effectiveness of the ergonomics program.	Employee performance. Employee knowledge and training. Work project	Hoffmeister, K., Gibbons, A., Schwatka, N., Rosecrance, J.	2015
fuzzy cognitive maps (FCM) methodology, Monte Carlo simulation	Environmental conditions	Communication and resources, work team, documented instructions about the job.	Training, instruction and education on safety and accident prevention, improvement in working conditions and job satisfaction. Pain and anguish because of work, work pressures	Asadzadeh, S. M., Azadeh, A., Negahban, A., Sotoudeh, A.	2013
Methods Nordic Occupational Safety Climate Assessment, Questionnaire was employed to evaluate safety climate in cross-sectional design.		Non-conformance and hazard management, participation of workers, organizational management structures, work team.	training	Givehchi, S., Hemmativaghef, E., Hoveidi, H.	2017

R. Ação Ergon., 15(2), 2021.
ISSN 2965-7318. doi: 10.4322/rae.v15n2.e202108.en

5. Conclusion

The results of the present study contribute to a greater understanding of the relative importance of how aspects of the physical, cognitive, and organizational domains of ergonomics are being addressed within the OSHMS, the guidelines of the approaches made by the researchers.

The main conclusions indicate that organizational aspects have gained strength in the management activities of companies, and they identified the need to focus risk prevention efforts on developing or strengthening the safety climate perceived by workers.

It is crucial to build trust on both sides, the management and the worker, so that the safety and proposed modifications are fruitful and not just compliance with legal requirements.

It is considered necessary to develop new research to define monitoring procedures considering the domains of specialization of cognitive and organizational ergonomics, allowing the identification of occupational risks with an interaction of the various factors present in occupational activities, not limited only to physical ergonomics. This global approach can contribute to the continuous improvement of the organization and the well-being of workers.

Thanks

This study was funded by the Coordination for the Improvement of Higher Education Personnel (CAPES) Brazil – Financing Code 001.

References

Abu-Khader, M. M. (2004). Impact of Human Behaviour on Process Safety Management in Developing Countries. Process Safety and Environmental Protection, 82(6), 431–437. https://doi.org/10.1205/psep.82.6.431.53206

Asadzadeh, S. M., Azadeh, A., Negahban, A., & Sotoudeh, A. (2013). Assessment and improvement of integrated HSE and macroergonomics factors by fuzzy cognitive maps: The case of a large gas refinery. Journal of Loss Prevention in the Process Industries, 26(6), 1015– 1026. https://doi.org/10.1016/j.jlp.2013.03.007

Boatca, M. – E., & Cirjaliu, B. (2015). A Proposed Approach for an Efficient Ergonomics Intervention in Organizations. Procedia Economics and Finance, 23(October 2014), 54–62. https://doi.org/10.1016/S2212-5671(15)00411-6

Cardoso, T. L., Ensslin, S. R., Ensslin, L., Ripoll-Feliu, V. M., & Dutra, A. (2015). Reflexões para avanço na área de Avaliação e Gestão do Desempenho das universidades: uma análise da literatura científica. Seminários Em Administração (XVIII SEMEAD). https://doi.org/http://sistema.semead.com.br/18semead/resultado/trabalhosPDF/205.pdf
Colombo, S., & Demichela, M. (2008). The systematic integration of human factors into safety analyses: An integrated engineering approach. Reliability Engineering and System Safety, 93(12), 1911–1921. https://doi.org/10.1016/j.ress.2008.03.029

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications, Inc.

De Oliveira Lacerda, R. T., Ensslin, L., & Ensslin, S. R. (2014). Research opportunities in strategic management field: A performance measurement approach. International Journal of Business Performance Management, 15(2), 158–174. https://doi.org/10.1504/IJBPM.2014.060165

Dutra, A., Ripoll-Feliu, V. ., Fillol, A. ., Ensslin, S. ., & Ensslin, L. (2015). The construction of knowledge from the scientific literature about the theme seaport performance evaluation. International Journal of Productivity and Performance Management, 64(2), 243–269. https://doi.org/10.1108/IJRDM-04-2015-0056

Ensslin, L, Ensslin, S. ., Dutra, A., Nunes, N. ., & Reis, C. (2017). BPM governance: a literature analysis of performance evaluation. Business Process Management Journal, 23(1), 71–86. https://doi.org/10.1108/BPMJ-11-2015-0159

Ensslin, Leonardo, Ensslin, S. R., & Pacheco, G. C. (2012). Um estudo sobre segurança em estádios de futebol baseado na análise bibliométrica da literatura internacional A study about safety in football stadiums based on bibliometric analysis of international literature.

Perspectivas Em Ciência de Informação, 17(2), 71–91. https://doi.org/10.1590/S1413-99362012000200006

Ensslin, S. R., Ensslin, L., Imlau, J. M., & Chaves, L. C. (2014). Processo de Mapeamento das Publicações Científicas de um Tema : Portfólio Bibliográfico e Análise Bibliométrica sobre avaliação de desempenho de cooperativas de produção agropecuária. Revista de Economia e Sociologia Rural, 52(3), 587–608. https://doi.org/10.1590/S0103-20032014000300010 Eskandari, D., Gharabagh, M. J., Barkhordari, A., Gharari, N., Panahi, D., Gholami, A., & Teimori-Boghsani, G. (2021). Development of a scale for assessing the organization's safety performance based fuzzy ANP. Journal of Loss Prevention in the Process Industries, 69(October 2020), 1–10. https://doi.org/10.1016/j.jlp.2020.104342

Garrigou, A., Peeters, S., Jackson, M., Sagory, P., & Carballeda, G. (2007). Contribuições da Ergonomia à Prevenção dos Riscos Profissionais. In Blucher (Ed.), Ergonomia (pp. 423–439). Givehchi, S., Hemmativaghef, E., & Hoveidi, H. (2017). Association between safety leading indicators and safety climate levels. Journal of Safety Research, 62, 23–32. https://doi.org/10.1016/j.jsr.2017.05.003

González, B. A., Adenso-Díaz, B., & González Torre, P. (2003). Ergonomic performance and quality relationship: An empirical evidence case. International Journal of Industrial Ergonomics, 31(1), 33–40. https://doi.org/10.1016/S0169-8141(02)00116-6

Haro, E., & Kleiner, B. M. (2008). Macroergonomics as an organizing process for systems safety. Applied Ergonomics, 39(4), 450–458. https://doi.org/10.1016/j.apergo.2008.02.018 Hoffmeister, K., Gibbons, A., Schwatka, N., & Rosecrance, J. (2015). Ergonomics Climate Assessment: A measure of operational performance and employee well-being. Applied Ergonomics, 50, 160–169. https://doi.org/10.1016/j.apergo.2015.03.011

IEA. (2019). International Ergonomics Association. Definition and Domains of Ergonomics. http://www.iea.cc

Iida, I., & Buarque, L. (2016). Ergonomia: Projeto e produção (3rd ed.). Blucher.

ISO. (2018). ISO 45001:2018 - Occupational health and safety management systems — Requirements with guidance for use (p. 47).

Kariuki, S. G., & Löwe, K. (2007). Integrating human factors into process hazard analysis. Reliability Engineering and System Safety, 92(12), 1764–1773. https://doi.org/10.1016/j.ress.2007.01.002

Kirwan, B. (1998). Safety management assessment and task analysis: A missing link? (pp. 67–92). Oxford: Elsevier. In A. Hale & M. Baram (Eds.), Safety management: The challenge of change (pp. 67–92).

Laing, a C., Cole, D. C., Theberge, N., Wells, R. P., Kerr, M. S., & Frazer, M. B. (2007). Effectiveness of a participatory ergonomics intervention in improving communication and psychosocial exposures. Ergonomics, 50(7), 1092–1109. https://doi.org/10.1080/00140130701308708.

Lima, F.P.A. et al. (2015). Barragens, barreiras de prevenção e limites da segurança: para aprender com a catástrofe de Mariana. Rev. bras. saúde ocup. [online], v. 40, n. 132, p. 118-120. https://doi.org/10.1590/0303-7657ED02132115.

Maggi, B., & Tersac, G. de. (2004). O trabalho e a abordagem ergonômica. In A ergonomia em busca de seus princípios: debates epistemológicos. Edgard Blucher.

Mattson Molnar, M., Von Thiele Schwarz, U., Hellgren, J., Hasson, H., & Tafvelin, S. (2019). Leading for Safety: A Question of Leadership Focus. Safety and Health at Work, 10(2), 180–187. https://doi.org/10.1016/j.shaw.2018.12.001

Mearns, K., Whitaker, S. M., & Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. Safety Science, 41(8), 641–680. https://doi.org/10.1016/S0925-7535(02)00011-5

Niu, S. (2010). Ergonomics and occupational safety and health: An ILO perspective. Applied Ergonomics, 41(6), 744–753. https://doi.org/10.1016/j.apergo.2010.03.004

Nunes, I. L. (2015). Integration of ergonomics and lean six sigma. A model proposal. Procedía Manufacturing, 3, 890–897. https://doi.org/10.1016/j.promfg.2015.07.124 Nwankwo, C. D., Theophilus, S. C., & Arewa, A. O. (2020). A comparative analysis of process safety management (PSM) systems in the process industry. Journal of Loss Prevention in the Process Industries, 66(June 2019). https://doi.org/10.1016/j.jlp.2020.104171

Payne, S. C., Bergman, M. E., Rodríguez, J. M., Beus, J. M., & Henning, J. B. (2010). Leading and lagging: Process safety climate-incident relationships at one year. Journal of Loss Prevention in the Process Industries, 23(6), 806–812. https://doi.org/10.1016/j.jlp.2010.06.004

Radjiyev, A., Qiu, H., Xiong, S., & Nam, K. H. (2015). Ergonomics and sustainable development in the past two decades (1992-2011): Research trends and how ergonomics can contribute to sustainable development. Applied Ergonomics, 46(PA), 67–75. https://doi.org/10.1016/j.apergo.2014.07.006

Sgourou, E., Katsakiori, P., Goutsos, S., & Manatakis, E. (2010). Assessment of selected safety performance evaluation methods in regards to their conceptual, methodological and practical characteristics. Safety Science, 48(8), 1019–1025. https://doi.org/10.1016/j.ssci.2009.11.001

Shikdar, A. A., & Sawaqed, N. M. (2004). Ergonomics, and occupational health and safety in the oil industry: A managers' response. Computers and Industrial Engineering, 47(2–3), 223– 232. https://doi.org/10.1016/j.cie.2004.07.004

Sinelnikov, S., Inouye, J., & Kerper, S. (2015). Using leading indicators to measure occupational health and safety performance. Safety Science, 72, 240–248. https://doi.org/10.1016/j.ssci.2014.09.010

Tamim, N., Laboureur, D. M., Hasan, A. R., & Mannan, M. S. (2019). Developing leading indicators-based decision support algorithms and probabilistic models using Bayesian network to predict kicks while drilling. Process Safety and Environmental Protection, 121, 239–246. https://doi.org/10.1016/j.psep.2018.10.021

Thomson Corporation. (2018). EndNote X9. Thomson Corporation.

Valmorbida, S. M. ., Ensslin, S. ., Ensslin, L., & Ripoll-Feliu, V. . (2016). Rankings universitários mundiais: que dizem os estudos internacionais? REICE. Revista Iberoamericana Sobre Calidad, Eficacia y Cambio En Educación, 14(2), 1–25. https://doi.org/10.15366/reice2016.14.2.001

Valmorbida, S. M. I., & Ensslin, S. R. (2015). Avaliação de Desempenho de Rankings Universitários: Revisão da Literatura e diretrizes para futuras investigações. Anais Do Encontro Da ANPAD (XXXIX EnANPAD 2015).

Vogt, J., Leonhardt, J., Koper, B., & Pennig, S. (2010). Human factors in safety and business management. Ergonomics, 53(2), 149–163. https://doi.org/10.1080/00140130903248801