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GETTING TO KNOW THE ERGONOMICS AND PERFORMANCE EVALUATION METHODS OF OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

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ABSTRACT: Considering that the most significant impact of accidents is on the worker themself, ergonomics with its systemic approach considering the domains of specialization can contribute to planning and executing the OHSMS, particularly with the use of more accurate indicators to evaluate the system's performance. This article aims to identify and characterize the methodologies and indicators used to assess the OHSMS through an RSL. To select and analyze articles on OHSMS evaluation methods, ProKnow-C was applied, using Advanced and Systemic Analyzes, to identify the types of methods and the organization's scope and participation. As a result, it was possible to identify that, in the 28 studies analyzed, a normative or descriptive approach was used, generic in 12 and specific in six. In contrast, the context was generic in three studies and specific in six. Furthermore, 28 selected works are based on generic indicators, 18 used Leading indicators, and ten used the combination of Lagging and Leading indicators without mentioning or analyzing the ergonomics domains of specialization. Likewise, it was evident that they did not analyze the organizational context to define the indicators. It is considered that the assessment components must be defined based on the organization's context, helping to identify the problems and critical situations that interfere with the risk management activities. Thus, the organization can define how to manage the workers and contribute to their well-being, allowing continuous improvements in the OHSMS. All of this supports the need to develop assessment methodologies using specific indicators to the organization's context.

KEYWORDS: Ergonomics. Occupational Health and Safety Management System. Performance evaluation. ProKnow-C.

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1 INTRODUCTION

Safety and health in productive systems directly correlate with ergonomics (or human factors), considering that the latter is a scientific discipline whose central focus is the human being, without disregarding the quality and productivity of organizations. It considers both the physical and mental abilities and limitations of workers and analyzes the relationship between work demands and human capabilities based on physical, cognitive, and organizational specialization (IEA, 2019).

In the Occupational Health and Safety Management System (OHSMS), people, technology, and work are usually analyzed in separate contexts. However, ergonomics achieves a systematic approach to human activity, allowing the contribution of the various scientific disciplines that comprise it. This results in a better adaptation of technology and work environments to the human being (ILO, 2019). Ergonomic intervention is considered successful in improving organizational activity in all its characteristics (Shikdar & Sawaqed, 2004).

Furthermore, it was identified that OHSMS performance evaluation is the most important component when the company is forming an OSH policy (Ale, Baksteen, Bellamy, Bloemhof, Goossens, Hale, Mud, Oh, Papazoglou, Post, & Whiston, 2008; Burke, Sarpy, Tesluk, & Crowe, 2002; Cox & Cheyne, 2000; Ramli, Watada, & Pedrycz, 2011; Sgourou, Katsakiori, Goutsos, & Manatakis, 2010; van Holland, de Boer, Brouwer, Soer, & Reneman, 2012; Wurzelbacher & Jin, 2011). Lagging or leading indicators are used in the OHSMS performance evaluation. However, lagging performance indicators generally measure past events and are not sensitive enough to identify changes in OHSMS performance (Lingard *et al*., 2011). These indicators measure failures (such as accidents or attendance rates) without revealing cause and effect (Sgourou *et al*., 2010). In some companies, leading indicators (capturing how well an organization is managing) are used, sometimes called positive performance indicators in OSH (Lingard *et al*., 2011; Sgourou *et al*., 2010). Thus, leading indicators measure positive measures to manage OSH before incidents or injuries occur (Lingard *et al*., 2011). In other cases, indicators of employee well-being and ergonomic interventions in the workplace were used in organizations (Hoffmeister *et al*., 2015).

The indicators can be quantitative (when used to quantify things that have occurred), for example, the number of injuries that occur in each period or the number of OSH inspections carried out, but without analyzing their characteristics or type of prevalence. Other indicators can be qualitative (referring to characteristics), such as describing workers' subjective judgments about management's commitment to OSH (Lingard *et al*., 2011).

It is necessary to know the methods and indicators used considering the importance of OHSMS performance measurement and the role of indicators to identify progress and possible continuous improvement strategies. Therefore, this article aimed to identify and characterize the methodologies and indicators used to the OHSMS performance evaluation.

2 RESEARCH METHODOLOGY

This research followed a constructivist approach based on the following activities: selection, analysis, and study of knowledge, acquisition of the main postulates, and construction of the theoretical framework (Dutra *et al*., 2015; L Ensslin *et al*., 2017; S. R. Ensslin *et al*., 2014; Valmorbida *et al*., 2016).

2.1 PROKNOW-C

It is based on a sequence of stages that help build researchers' knowledge and its subsequent organization and use, according to their boundaries and interests (Dutra *et al*., 2015; L Ensslin *et al*., 2017). In this process, the researchers defined database selection criteria, keywords, time filters, and, mainly, parameters for inclusion and exclusion of literature in the Bibliographic Portfolio (L Ensslin et al., 2017; S. R. Ensslin *et al*., 2014).

ProKnow-C is structured in four stages (Figure 1): (i) selection of the bibliographic portfolio; (ii) bibliometric analysis; (iii) systemic analysis; and (iv) question family and research objectives (Cardoso *et al*., 2015; Dutra *et al*., 2015; L Ensslin *et al*., 2017; S. R. Ensslin *et al*., 2014; Valmorbida *et al*., 2016).

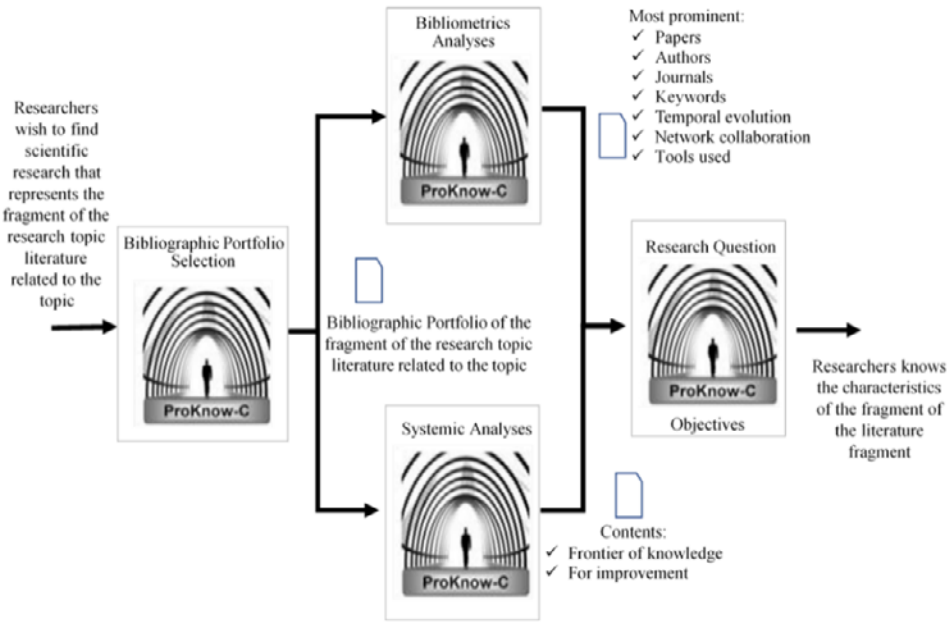

Figure 1: ProKnow-C Stages (Leonardo Ensslin et al., 2012).

2.2 PROCEDURES FOR THE OHSMS PERFORMANCE ASSESSMENT BIBLIOGRAPHIC PORTFOLIO

The selection of the bibliographic portfolio began with the creation of the Gross Database (BDB), which involves: (i) definition of keywords; (ii) definition of databases; (iii) search of scientific articles in selected databases; and (iv) keyword adherence test (Dutra *et al*., 2015; L Ensslin *et al*., 2017; S. R. Ensslin *et al*., 2014; Valmorbida *et al*., 2016).

Seven databases were consulted: Scopus; Web of Science; Science Direct; Compendex; ProQuest; EBSCO Academic Search Premier; and Wiley Online Library. Then, the limits of the search process were defined: (i) articles published in scientific journals; (ii) articles published from 2000 to 2019; (iii) search the databases with keywords in the title, abstract, and keywords of the articles; and (iv) articles published in English. Access to the databases was carried out through the network of the Federal University of Santa Catarina (UFSC). The EndNote® X9 software (Thomson Corporation, 2013) was used to manage the articles obtained from the databases used in the research process.

This BDB was filtered by applying the sequence shown in Figure 2. Articles that analyzed the performance evaluation of the OHSMS or presented a case study with a methodology to evaluate the OHSMS were selected.

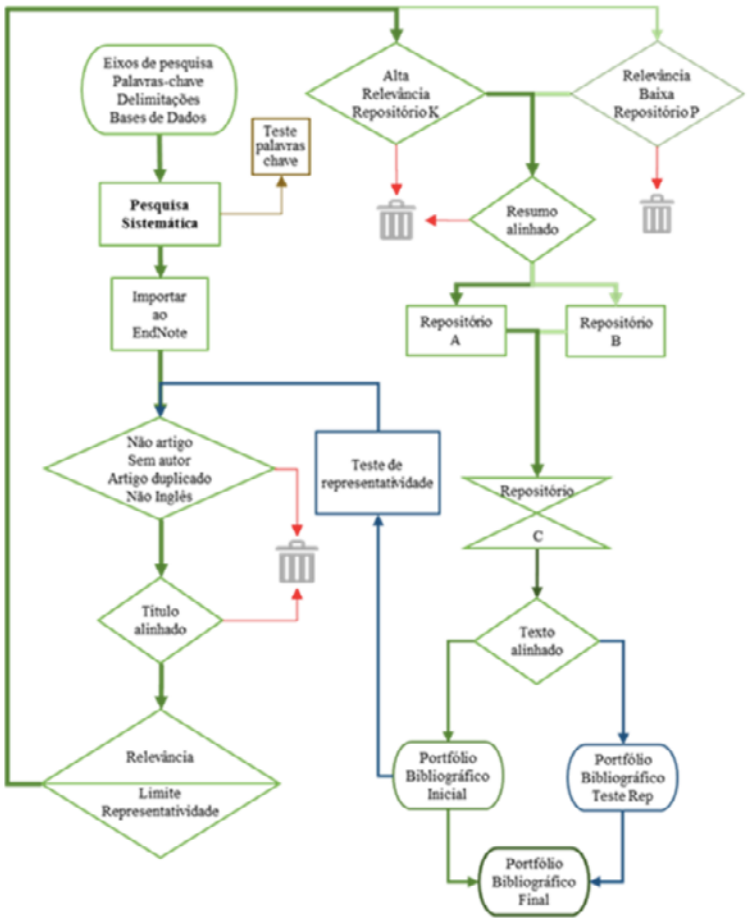

Figure 2: Composition of the bibliographic portfolio: filtering and representativeness test

Thus, bibliometric and systematic analyzes were carried out, described in section 4, after selecting a literature fragment on OHSMS performance evaluation, according to the boundaries and focus of the researcher's interest.

2.3 PROCEDURES FOR DATA ANALYSIS: BASIC AND ADVANCED BIBLIOMETRICS, SYSTEMATIC ANALYZES, AND RESEARCH OPPORTUNITIES

These are the second and third stages of ProKnow-C - bibliometric and systematic analysis - focused on quantitative and qualitative evidence of the information in the papers. Basic bibliometric analysis characterized the articles in the following variables: (i) prominent authors; (ii) scientific recognition of the articles; (iii) keywords that best represent the subject and/or the most used; (iv) outstanding scientific journals and their impact factor (Dutra *et al*., 2015; L Ensslin et al., 2017; S. R. Ensslin *et al*., 2014; Valmorbida *et al*., 2016); (v) temporal evolution of the publications; (vi) collaboration network between authors and co-authors, by country of origin and institution of affiliation; and (vii) tools used (in empirical studies) (Cardoso *et al*., 2015; Valmorbida & Ensslin, 2015). Additionally, advanced bibliometric analyzes included: (i) design of the performance evaluation system and analysis of levels (individual performance measures or set of measures, and the relationship between the performance measurement system and the environment); (ii) identification of measures/metrics/characteristics of key performance indicators (Figure 3): the systems developed for performance management; (iii) dimensions included in the analyses, the relationship between the objectives (aspects) analyzed and the Organization's strategy; and (iv) stakeholder participation (OTLEY, 2001).

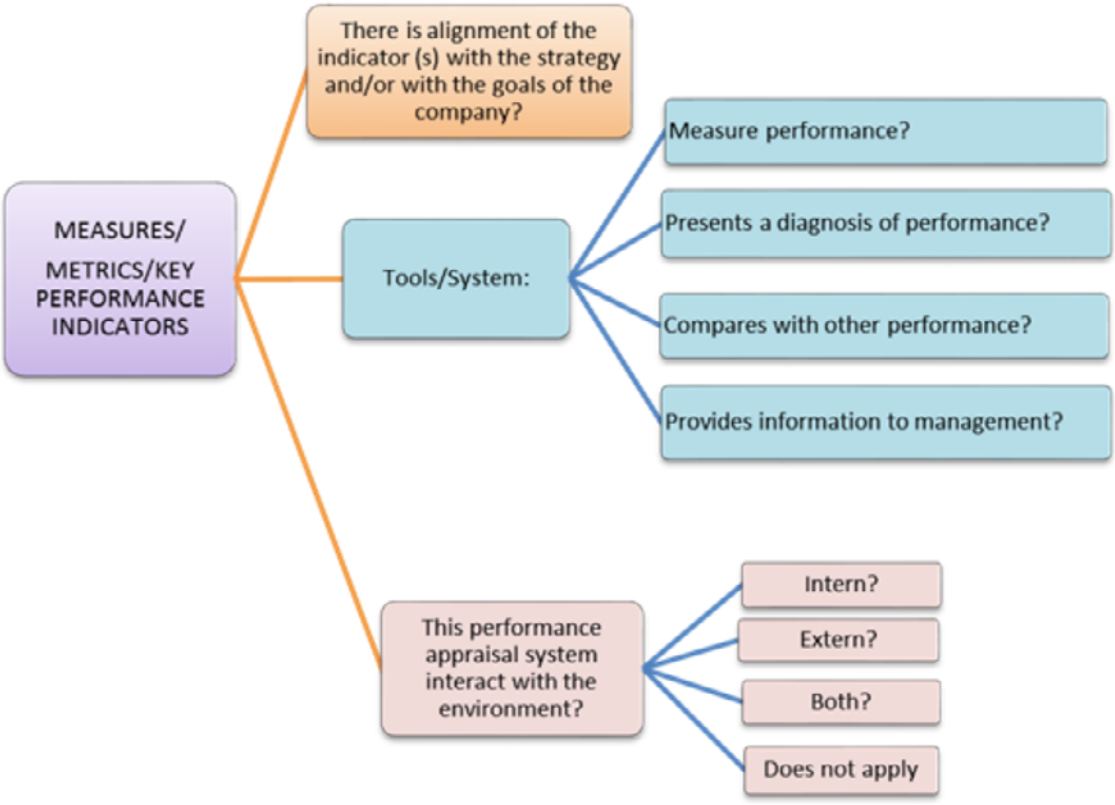

Figure 3: Performance Measurement System Design (Developed by the authors).

Subsequently, systematic analyzes were performed regarding the: (i) approach and harmony (Lacerda, Ensslin, Ensslin, 2014) (Table 1); (ii) the uniqueness of the authors (Table 2); (iii) the uniqueness about the physical context; and (iv) the identification of the method's purposes to determine its legitimacy (Lacerda, Ensslin, Ensslin, 2014) (Table 3). The legitimacy is identified as the authors recognize the limits of knowledge for the company's decision makers under analysis and identification of process goals and method criteria. It is considered that the valuation method is legitimate when specifically built for the organization in which it is being applied. When constructing the assessment method, it was also analyzed whether the researchers recognized the need to increase the decision maker's knowledge about how the context can influence their interests, values, and preferences (Lacerda, Ensslin, Ensslin, 2014).

Table 1 - Approach and harmony (Developed by the authors)

Model/Data	Use/Application	Harmony
Realistic (Normative or Descriptive)	Generic	YES
	Specific	NO
Prescriptive or Constructivist	Generic	YES
	Specific	NO

Table 2 - Singularity about actors (Developed by the authors)

Identification	Use/Application	Harmony
YES	YES	YES
	NO	NO
NO	NO	NO

Table 3 - Legitimacy Model (Developed by the authors)

Decisor-maker	Values and preferences	Legitimacy
All process participation	Integral	YES
	Partial	YES
	Only final validation	YES
	No participation	NO
Initial phase only	Integral	YES
	Partial	YES
	Only final validation	YES
	No participation	NO
No participation	No participation	NO

3 THEORETICAL FRAMEWORK

3.1 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM (OHSMS)

The Safety and Health at Work program is a strategy to reduce occupational injuries and illnesses. Voluntary OSH guidelines have been developed in several countries, such as the US Occupational Safety and Health Administration (OSHA) (LaMontagne *et al*., 2004) or OHSAS 18001 (Khodabocus & Constant, 2010), among others. Occupational health and safety activities must be implemented in companies, regardless of economic activity, to ensure the management of occupational risks.

The OHSMS has procedures that help an organization comply with legal obligations involving its occupational hazards and establish organized processes that seek to promote continuous improvement in safety and healthy working conditions. These procedures are policies, strategies, practices, procedures, and functions related to protection and well-being (Fernández-Muñiz *et al*., 2007). The OHSMS has instruments to manage the risks that can affect the health and safety of people in their workplaces (Fernández-Muñiz *et al*., 2007). These prevention activities are associated with the concept of continuous improvement through 'control loops', which involve planning, work organization, implementation, evaluation, verification of the result concerning planning, and adjustment/execution of corrective actions.

Furthermore, the security process is recognized as an important aspect of the organization to avoid human and financial losses. The ability to promote workforce participation and decentralize decision-making on this issue are considered factors that generate the efficiency of the OHSMS (Fernández-Muñiz *et al*., 2007). Likewise, safety performance assessment is considered an essential part of the OHSMS as it provides information about the quality and evolution of the system. Thus, safety performance evaluation supports decision-making in occupational safety and health strategies (Sgourou *et al*., 2010).

Control activities include incident reporting, performance indicators, auditing and reviewing, continuous monitoring, evaluating, and improving the performance of operations and activities. Proper measures can provide managers with more information and show compliance with standards. A security audit can help identify the strengths and weaknesses of the OHSMS. Furthermore, any problem areas that could negatively affect the program's success should be identified.

The OHSMS is focused on the organization's need to meet stakeholder requirements. Thus, the control of risks at work can be successfully handled by an OHSMS. This system must have indicators to assess compliance with laws and regulations and measure the efficiency of control activities.

3.2 OHSMS EVALUATION METHODS

With increasing interest and the need to apply the OHSMS, some specialists and researchers are choosing a method that best suits the company's needs. Some methods to assess the OHSMS have been emerging in recent years, including those shown in Table 4

Table 4 - OHSMS Evaluation Methods

Method	Author
Evaluation of the Elements of Occupational Safety and Health Management Systems (OHSMS)	(Podgorski, 2000)
Safety Climate Assessment Toolkit	(Cox & Cheyne, 2000)
Sociotechnical model of safety culture	(Grote & Künzler, 2000)
CIDA's Health and Safety Continuous Improvement Matrix	(Lin & Mills, 2001)
Universal Assessment Instrument (UAI)	(Redinger *et al*., 2002a, 2002b)
4-factor model of general safety performance	(Burke *et al*., 2002)
Malcolm Baldrige Criteria for Performance Excellence	(Ketola *et al*., 2002)
Adapted an Occupational Safety and Health Administration (OSHA) survey	(Barbeau *et al*., 2004)
Wellworks-2	(LaMontagne *et al*., 2004)
Norway's model modification	(Torp & Moen, 2006)
Analytic Hierarchy Process (AHP) methodology	(Law *et al*., 2006)
Self-diagnostic OHS tool	(Cadieux *et al*., 2006)
Multidimensional scale	(Fernández-Muñiz *et al*., 2007)
'Stage of Change' and 'Business Activity Models'	(Deighan et al., 2009)
Risk Analysis Methodology	(Khodabocus & Constant, 2010)
Safety Element Method (SEM), Universal Assessment Instrument (UAI), Safety Culture Questionnaire (SCQ), Safety Diagnosis Criteria (SDC), Occupational Health and Safety Self-Diagnostic Tool (OHSSDT), The pyramid of chemical major accident prevention (PyraMAP)	(Sgourou *et al*., 2010)
Hierarchical model for the measurement of OHS performance	(Lingard *et al*., 2011)
Workers compensation (WC) outcomes	(Wurzelbacher & Jin, 2011)
FLESH study (Functional Labour Evaluation for Sustained Health and employment)	(van Holland *et al*., 2012)
Mixed-methods approach	(Seixas *et al*., 2013)
HFACS-MA (human factors/ergonomics (HF/E) based classification system - Maintenance Audit)	(Y.-L. Hsiao *et al*., 2013; Y. L. Hsiao *et al*., 2013)
HIRARC model	(Saedi *et al*., 2014)

Method	Author
Ergonomics Climate Assessment	(Hoffmeister *et al.*, 2015)
The multi-phase development process of an FTO assessment tool	(Curcuruto *et al.*, 2017)
"Last mile" problem	(Zhao *et al.*, 2018)
Integrated Fuzzy Cognitive Map–Bayesian Network Model	(Pourreza *et al.*, 2018)

Some types of metrics used in OSH programs were identified in these methods. Likewise, two types of security measures are common: accountability measures and performance indicators. Leading indicators are used to measure the positive steps to manage OSH before incidents or injuries occur (Lingard *et al.*, 2011). Some examples of leading and lagging indicators are presented in Table 5.

Table 5 - Evaluation Indicators

Leading	Lagging
• Employee turnover rate	• Injury frequency and severity
• Number of third-party certifications achieved	• Near misses (frequency, trend)
• Percentage of employee training completed vs. expected	• Fatality or other accidents
• The frequency of completed inspections vs. scheduled inspections	• Lost workday rate
• Number of new or enhanced safety controls implemented	• Chemical releases
• Results of observations and accident investigation results	• OSHA citations (number of citations and type)
• Risk or hazard assessments and job hazard analysis	• Workers' compensation claims (trends and amounts)
• Employee perception surveys	• Experience modification rate (the rate and any changes)

3.3 PERFORMANCE EVALUATION

Performance evaluation can be defined as the process of quantifying the efficiency and effectiveness of actions (Neely, 1999). A metric used to quantify the efficiency and/or effectiveness of actions. The set of metrics used to quantify both the efficiency and effectiveness of the action. It must be derived from the strategy to reinforce the importance of the strategic variables (Neely *et al.*, 1995).

It is used to assess, manage, and improve processes within the company and compare performance between different departments or with other organizations. These strategies evolve when decisions are made and actions are pursued (Neely *et al.*, 1995).

Traditional performance measures are metrics as a result of past decisions (Ghalayini & Noble, 1996). Performance evaluation has developed new features to evolve in the measurement process despite being called non-traditional (Ghalayini & Noble, 1996). It is designed to provide managers, supervisors, and operators with timely information to make decisions. Furthermore, new features are proposed to have performance measures.

Among the characteristics of non-traditional performance measures are: (i) they are based on the company's strategy; (ii) non-financial measures; (iii) intended for all employees; (iv) on-time metrics (hourly or daily); (v) simple, accurate, and easy to use; (vi) lead to employee satisfaction; (vii) are often used on the shop floor; (viii) they do not have a fixed format (depends on needs); (ix) vary between locations; (x) changes over time in line with changing needs; (xi) intended to improve performance; (xii) applicable; (xiii) helps to achieve

continuous improvement (Ghalayini & Noble, 1996).

In addition to the characteristics of traditional and non-traditional performance measurement, there are seven reasons to understand the importance of measuring business performance: (i) the changing nature of work; (ii) outperforming the competition; (iii) specific improvement initiatives; (iv) national and international awards; (v) changing organizational roles; (vi) change in external demands; and (vii) the power of information technology (Neely, 1999).

Also, the performance appraisal system must include some effective mechanism for reviewing and reconsidering targets and standards (Ghalayini & Noble, 1996). A mechanism that allows you to periodically review the comprehensive set of measurements in use. Metrics and goals can evolve naturally during its use but must be verified so that evolution remains aligned with the organizational strategy (Ghalayini & Noble, 1996).

Performance appraisal changes the way people interact with information before and after the system is implemented. This contributes to changing administrative procedures, which modify other characteristics, such as communication and human aspects involving attitudes, beliefs, values, skills, and behaviors (Bititci *et al*., 2012).

4 RESULTS AND DISCUSSIONS

With the research carried out in the seven databases, 4978 documents were imported, and 28 were selected after the debugging process. This section presents the results of the articles' characteristic analysis, variables described in section 2.4.

4.1 BIBLIOMETRIC ANALYSIS: BASIC CHARACTERISTICS

In the 28 articles selected in this research, 82 authors participated, considering that each author participated in one research. The identification criterion for prominent authors was the number of article citations (Figure 4).

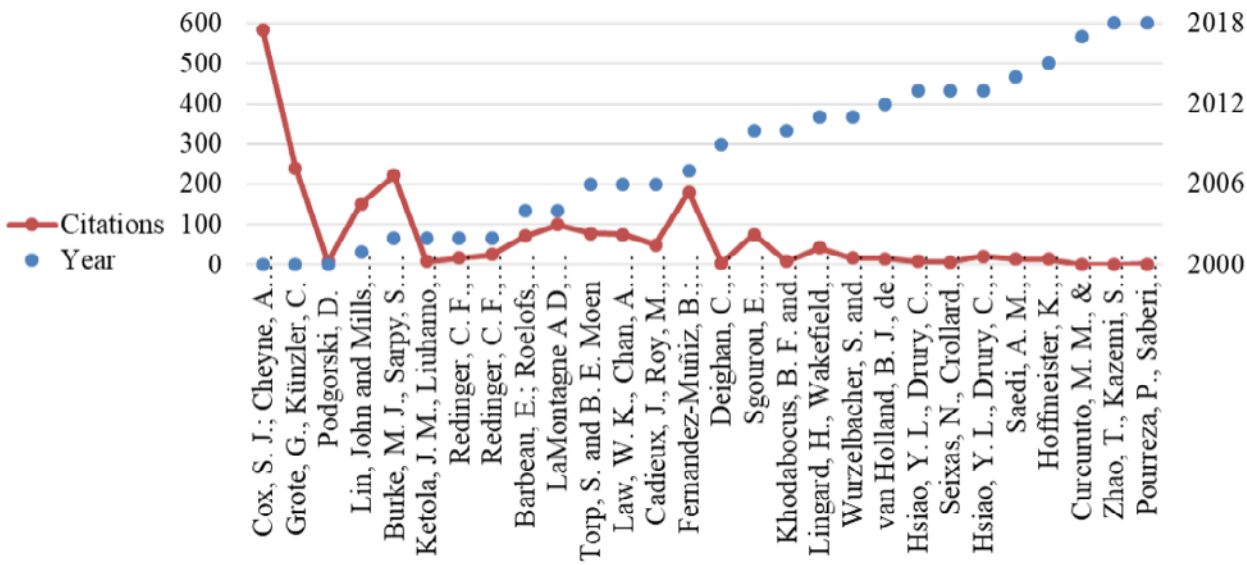

Figure 4: Prominent articles (Developed by the authors).

The most prominent article in this fraction of the literature was “Assessing safety culture in offshore environments” with 584 citations, written by Susan Cox and Alistair Cheyne. It was published in the journal Safety Science in 2000. This article considers the concept of safety culture and safety climate assessment. Its preliminary results illustrate some of the relationships between different measures, especially those related to work and supportive and engaging environments.

The second article was “Diagnosis of safety culture in safety management audits” with 240 citations. It is the result of research conducted by Gudela Grote and Cuno Künzler. It was published by Safety Science in 2000. The article concerns obtaining data on safety-related perceptions. The authors complement and expand on the information obtained from expert interviews and workplace observations during safety audits. The authors developed a questionnaire to support audits, analyzing safety management and the safety culture in a company as a complement to methods designed to assess formal safety audit management. The study provided data related to operational safety, safety strategies and design, and personal work needs.

And the third article, with 222 citations, was “General safety performance: a test of a grounded theoretical model” by Michael Burke, Sue Ann Sarpy, Paul Tesluk, and Kristin Smith-Crowe. It was published by Personnel Psychology in 2002. This article empirically assesses the overall SST performance method that is potentially applicable to safety performance in many work domains. They present the relationships between indicators of breadth and depth of knowledge constructs and safety performance factors confirmed with historical data from training and supervision.

The following basic analysis identifies the keywords that best represent the subject. Knowing these keywords, researchers will have greater opportunities to collect articles aligned with the search. The VOSviewer software was used to illustrate this analysis (Figure 5).

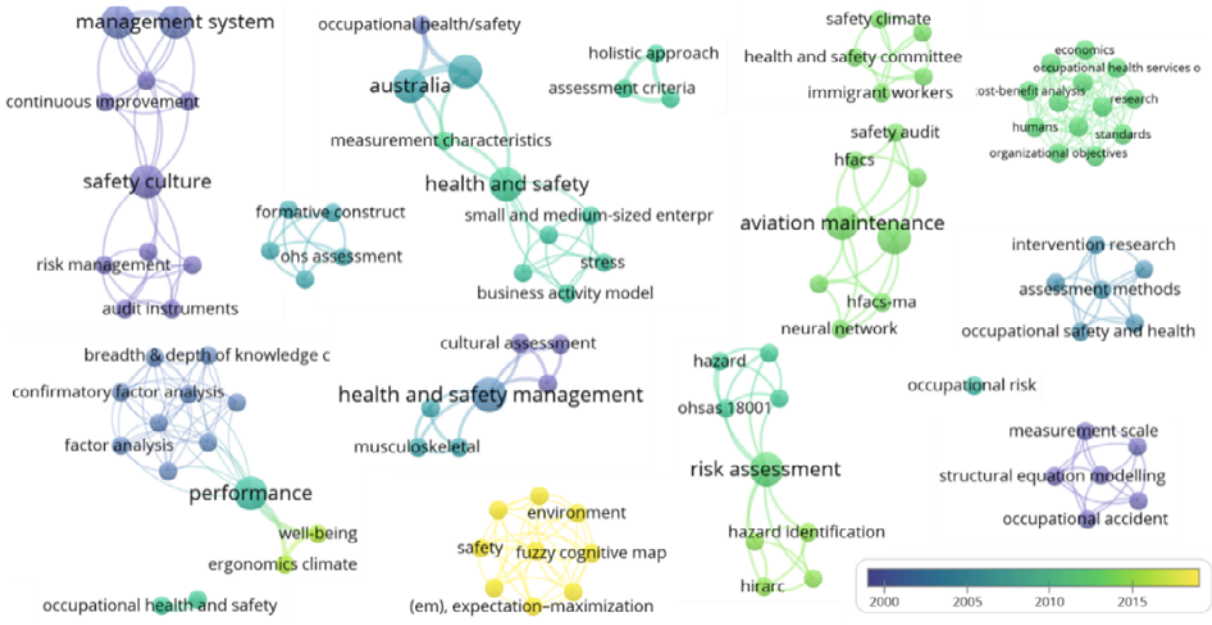

Figure 5: Main keywords in the literature fragment (Developed by the authors from VOSviewer).

The figure above shows the keywords used in each article and their network of connections. When the keyword is used in multiple articles, the circle is displayed in a larger size, and the lines create a web of connection between the keywords. The color corresponds to the year

of publication of the article, shown in the bottom bar. There was little interaction between keywords in the 28 articles. Only five of them (Health and safety, Safety culture, Health and Safety Management, Performance, risk assessment) were used in two articles.

Concerning the analysis of prominent scientific journals, in the literature fragment, and its Impact Factor (IF), it was possible to identify that 14.28% of the papers were published in Safety Science and Applied Ergonomics. Still, Safety Science has a higher impact factor (Figure 6). Safety Science is a multidisciplinary journal created in 1989, produces ten volumes a year, and has an impact factor of 2.835. The Impact Factor measures the average number of citations received in a year for articles published in the journal during the last two years.

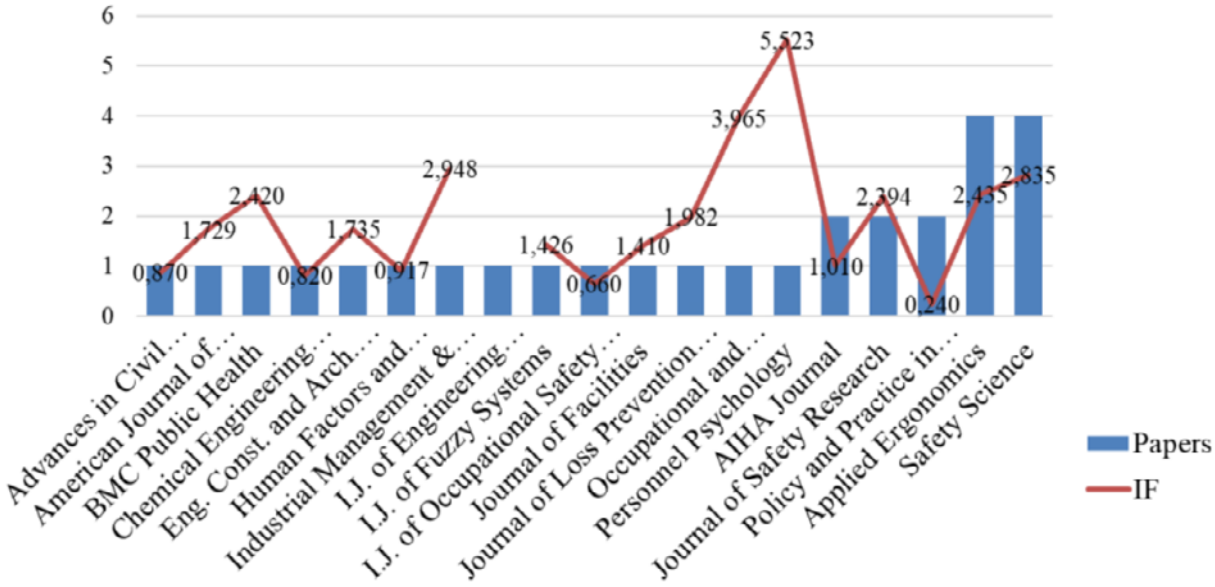

Figure 6: Prominent scientific journals (Developed by the authors).

When analyzing the Temporal Evolution of this fragment of literature, it is possible to identify that the evaluation of the safety culture increases researchers' interest. Some studies have recently shown tools to measure OHSMS. In a study published in 2000 by Safety Science, Cox and Cheyne described some tools to measure the effectiveness of OHSMS. The authors developed a self-assessment tool to measure performance (Cox & Cheyne, 2000). In the same year, Grote and Künzler structured a questionnaire to assist the OHSMS audit process (Grote & Künzler, 2000). In 2001, John Lin and Anthony Mills established a CIDA (Construction Industry Development Agency)-based questionnaire to assess the OHSMS in 44 companies (Lin & Mills, 2001). In 2002, the team led by Burke empirically evaluated the overall SST performance method (Burke *et al*., 2002). In 2004, the team of researchers led by LaMontagne proposed an OSHA assessment profile adapted to verify the assessment of effectiveness in 15 workplaces (LaMontagne *et al*., 2004).

In 2006, Torp and Moen investigated the effects of implementing or improving the OHSMS in small and medium-sized enterprises (Torp & Moen, 2006). Law's team identified seven criteria to prioritize the elements that allow the effective implementation of OHSMS in three types of industry (Law *et al*., 2006). The following year, Fernandez-Muñiz' and collaborators created a method to assess the OHSMS in 455 companies in Spain (Fernández-Muñiz *et al*., 2007).

In 2010, Sgourou's team assessed six methods of evaluating security performance. They used six assessment elements to define five levels of safety performance (Sgourou *et al*., 2010). In 2013, the team led by Hsiao developed a different method to assess OHSMS audits

(Y. L. Hsiao *et al*., 2013). In 2014, Saedi's team developed a method to measure, diagnose, and generate OSH management reports (Saedi *et al*., 2014). In 2017, Curcuruto and Griffin created a multidimensional questionnaire as a tool to assess the safety capacity of real industrial operators to understand and assess their "fitness-to-operate" (FTO) (Curcuruto *et al*., 2017). Then, in 2018, Zhao's team developed a questionnaire with 34 aspects to assess the OSH, identifying the critical points (Zhao *et al*., 2018). None of these methods analyzed or considered the specialization domains of ergonomics.

Finally, the tools used in the surveys were identified. These 28 papers were chosen because they described or used a method to measure the OHSMS evaluation. Table 6 shows the characteristics of these performance evaluation methods, what type of industry was applied, the user involved in the evaluation process, what type of tool was used, and how many elements and sub-elements compose it.

Table 6 - Overview of OHSMS performance evaluation methods

Method	Industry	Users	Type of method	Ele ments	Sub-ele ments
Existing performance evaluations methods					
Safety Element Method (SEM)	Mining	Employees	Subjective evaluation of the level of performance	6	12
Universal Assessment Instrument (UAI)	Various	Auditors	Audit/ benchmarking tool	27	118
Safety Culture Questionnaire (SCQ)	Process (petrochemical)	Auditors	Questionnaire	47	47
Safety Diagnosis Criteria (SDC)	Various	Employees	Subjective evaluation of the level of performance	13	140
Occupational Health and Safety Self-Diagnostic Tool (OHSSDT)	Various (semiautono-mous workgroups)	Employees	Subjective evaluation of the level of performance	9	67
The pyramid of chemical major accident prevention (PyraMAP)	Process (major hazard chemical)	Auditors	Inspection/audit/accident investigation tool	Depends on its application	
4-factor model of general safety performance	Nuclear waste site, ha-zardous waste workers	Coworker (peer) appraisals from employees	Confirmatory factor analytic tests	4	27
Norway's model	Motor vehicle repair garages	Managers and blue-collar workers	Self-administered questionnaires	12	45
Analytic Hierarchy Process (AHP) methodology	Textile, clothing, printing, electronics and publishing	Safety personnel, ex-perts and professionals	Interview, questionnaires	7	13
A hierarchical model for the me-asurement of OHS performance (Project safety index and OHS climate survey)	Construction	OHS responsible	Site safety walks. Multiple measures of OHS performan-ce, including leading indica-tors and perception surveys	2	23
Malcolm Baldrige Criteria for Performance Excellence	Small and medium sized enterprises	Project team in each company	Self-assessment meetings	8	85
Risk Analysis Methodology	Printing	Management and employees	Walkthrough survey, risk assessment form	4	
Stage of Change and Business Activity Models	Small and medium-sized enterprises	Person responsible for health and safety	Semi-structured interviews, questionnaire	2	38
Adapted an occupational safety and health administration (OSHA) survey	Small businesses	Directors, workers	Survey	4	47

Method	Industry	Users	Type of method	Ele ments	Sub-ele ments
Existing performance evaluations methods					
HIRARC model	Various	Auditors	Inspection/audit/accident investigation tool	6	14
Wellworks-2	Manufacturing	OSH managers	Interviews	4	91
Multidimensional scale	Building, industrial and services sectors	Safety officer	Questionnaire	6	43
CIDA's Health andSafety Continuous Improvement Matrix.	Construction	OHS responsible	Questionnaire	14	
Universal Assessment Instrument (UAI)	Manufactured	EHS manager	Interviews, observations, and documents/ records	4	17
Multi-phase development process of a FTO assessment tool	High-risk industries	Managers	Multidimensional survey questionnaire	23	130
Integrated Fuzzy Cognitive Map–Bayesian Network Model	Power plants	HSE managers	Questionnaire	30	
New performance evaluations methods					
Safety Climate Assessment Toolkit	Process (petrochemical)	Auditors	Inspection/audit/accident investigation tool	45	115
SPE method	Process (construction)	Auditors	Questionnaire	6	12
FLESH study, (CSQ-8)	Process	Auditors	Questionnaire	27	118
WC outcomes	Process	Employees	Subjective evaluation of level of performance	6	12
HSC training intervention. A mixed-methods approach	Various	Employees	Subjective evaluation of level of performance	27	118
HFACS-MA	Various	Auditors	Inspection/audit/accident investigation tool	6	12
Sociotechnical model of safety culture	Petrochemical plants	Auditors	Questionnaire	3	57
Ergonomics Climate Assessment	Various	Auditors	Questionnaire	32	68
Risk Analysis Methodology	Various	Auditors	Questionnaire	6	42
Interviews connections TQM e OHS	Various	Employees	Questionnaire	27	130
Self-diagnostic OHS tool	Various	OHS committee	Worker's observations, Questionnaire	9	67
Last mile problem	Construction	Managers	Questionnaire	5	34

4.2 ADVANCED BIBLIOMETRIC ANALYSIS

This analysis begins with the characterization of the design and analysis of the performance evaluation system, the levels (individual performance measures or set of measures), and the relationship between the performance measurement system and the environment, presented in Figure 3. It was possible to identify that all methods applied by the authors are a set

of measures. These studies conducted a review of the scientific literature on metrics and indicators. Additionally, the authors proposed changes to existing procedures or methods and then tested their application. In some cases, they consulted experts who chose key metrics and indicators based on their perceptions.

The procedure or methods proposed by the researchers for the performance appraisal system had a different design (Figure 7). Of these 18 studies measuring performance, ten had a performance diagnosis. In nine cases, the studies involved different companies, and the authors compared performance. Furthermore, eight surveys included or provided information for the company to improve its management. It is worth noting that, in some cases, a combination of results was presented in the article (measurement and diagnosis, measurement and comparison, measurement and management report, or diagnosis and management report).

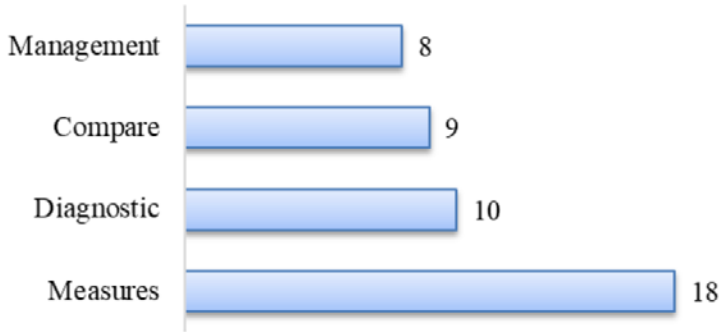

Figure 7: Performance evaluation system design results.

It was possible to identify that several dimensions were included in the analyses of the surveys when reviewing the systems developed for performance management. The authors considered the relationship between the objectives (aspects) analyzed and the organization's strategy to create the tool or method in only 16 cases (Cadieux *et al*., 2006; Curcuruto *et al*., 2017; Grote & Künzler, 2000; Hoffmeister *et al*., 2015; Y.-L. Hsiao *et al*., 2013; Y. L. Hsiao *et al*., 2013; Ketola *et al*., 2002; Khodabocus & Constant, 2010; LaMontagne *et al*., 2004; Podgorski, 2000; Podgórski, 2015; Redinger *et al*., 2002b; Saedi *et al*., 2014; Seixas *et al*., 2013; Sgourou *et al*., 2010; van Holland *et al*., 2012; Wurzelbacher & Jin, 2011). The other researches considered variables/indicators/generic aspects.

It was possible to identify that 17 surveys considered the interested parties (Figure 8) (Barbeau *et al*., 2004; Burke *et al*., 2002; Cox & Cheyne, 2000; Deighan *et al*., 2009; Fernández-Muñiz *et al*., 2007; Grote & Künzler, 2000; Y. L. Hsiao *et al*., 2013; Khodabocus & Constant, 2010; Law *et al*., 2006; Lingard *et al*., 2011; Podgorski, 2000; Pourreza *et al*., 2018; Redinger *et al*., 2002b; Seixas *et al*., 2013; Sgourou *et al*., 2010; van Holland *et al*., 2012; Zhao *et al*., 2018).

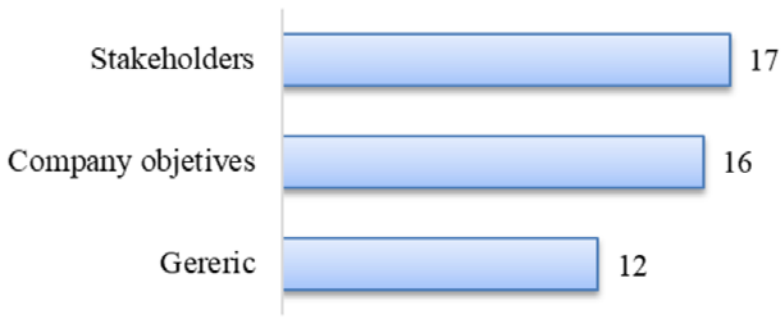

Figure 8: Consideration of stakeholders in the process.

4.3 SYSTEMIC ANALYSIS

The first “lens” of the systematic review concerns the approach used in the articles. The analysis of this lens is complemented by the search for the context in which the method is applied: either general or specific, as shown in Table 1. When considering both analyses, it was possible to identify the harmony in the studies. There is harmony when the approach used and the application context follow the same line. As a result, 15 of the methods were found to be in harmony (Figure 9).

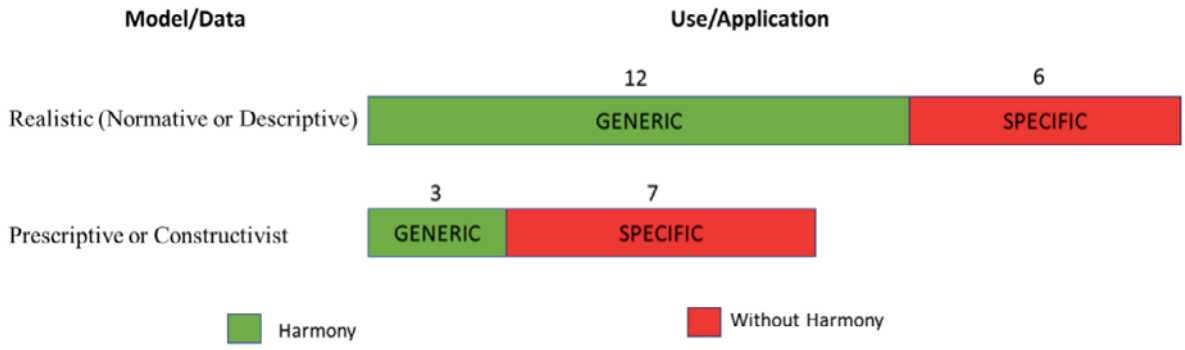

Figure 9: Approach, Context and Harmony.

The second variable is Singularity (lens 2), which analyzes how the environment was considered and whether decision-makers participated and were identified (Table 2). This lens is subdivided into two analyses. In the first, the uniqueness of the authors is studied. In the second, if the researchers identified the uniqueness of the physical context (Figures 10 and 11).

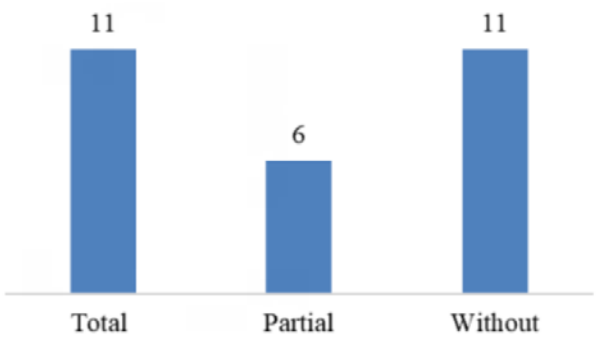

Figure 10: Uniqueness of authors.

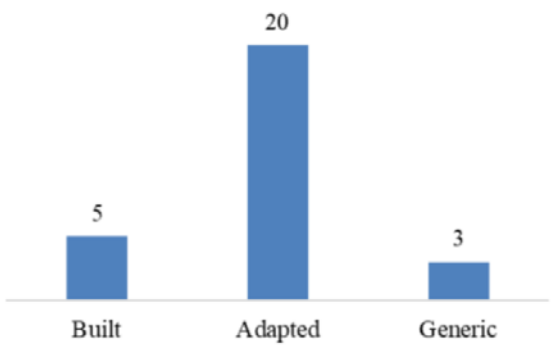

Figure 11: Uniqueness of the physical context.

As a result, the method used in seven surveys was considered unique, 12 have partial uniqueness, and nine do not (Figure 12).

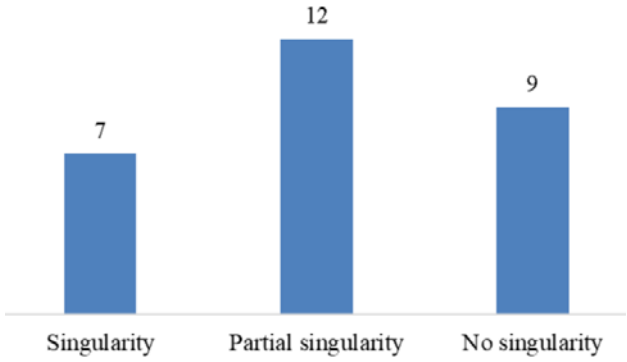

Figure 12: Uniqueness of method.

The next variable was the identification of objectives (lens 3), shown in Table 3. The first analysis, from this lens, shows that most studies do not consider the expansion of knowledge of decision-makers. The second analysis of lens 3 identifies the method's objectives/criteria; 13 identified them. With the combination of the participation of decision-makers and the organization's values and preferences, ten methods can be considered with legitimacy since they were developed considering the organizational characteristics fully and five partially.

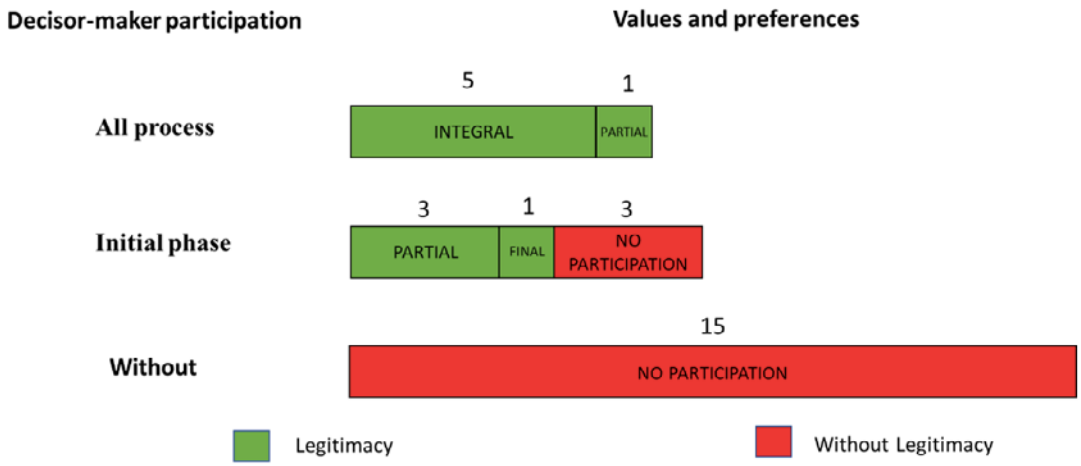

Figure 13: Legitimacy Identification.

These analyses confirm that the analyzed methods' objectives/variables/criteria do not identify the need to expand the decision-makers' knowledge. In particular, it confirmed that they did not identify how the context affects interests, values, and preferences (Ensslin; Ensslin; E Dutra, 2015; Ensslin *et al*., 2015), although they considered the characteristics of the organization.

5 CONCLUSIONS

This work enabled the selection and analysis of the characteristics of international scientific publications that discuss the OHSMS performance evaluation methods, characterizing the

methodologies and indicators used to assess the OHSMS.

The ProKnow-C supported the selection of scientific articles that work on the subject with systemic and advanced analysis, allowing the identification of research gaps. Likewise, it allowed us to immerse ourselves in the scientific knowledge of the OHSMS performance evaluation methods.

Advanced variable analyzes have provided research opportunities for studies that discuss OHSMS performance evaluation methods, including considering all stakeholders, the organization's context, and the use of ergonomics domains of expertise to define indicators, leading to a method adjusted to the specific needs of the organization and its context to obtain a robust management system and contribute to continuous improvement.

The systematic review was carried out from a constructivist performance evaluation perspective. Three lenses from the constructivist perspective were analyzed. Research opportunities were identified concerning the development of a constructivist method to assess the performance of the occupational health and safety management system and its interaction with physical, cognitive, and organizational ergonomics, equally emphasizing on indicators adjusted to the organization's characteristics, the decision maker's intervention, and influence to define the performance evaluation required to contribute to continuous improvement.

Considering that each organization has different aspects, objectives, physical context, risk level, and controls, its performance measurement must be based on specific indicators since both the method and its indicators must be developed, contributing to the recognition of the decision-maker's knowledge limits and generating continuous improvement in the OHSMS.

Prevention activities are structured and implemented by organizations that measure their execution. However, contributions to managing risk and workers' well-being are not measured. Consequently, the lack of an assessment method involving the organization's context and the physical, cognitive, and organizational domains of ergonomics is identified as a research gap. Performance indicators must be defined to assess the management of occupational risks according to the organization's context and contribute to the provision of strategies to the organization's continuous improvement.

The research opportunities and practical challenges established a starting point for creating methods to assess the performance of the Occupational Health and Safety Management System. This study recommends research that allows proposing new metrics to assess the performance of the OHSMS, which is still little explored in the literature. In this case, new indicators and forms to measure the OHSMS can be developed or identified for different contexts.

This study has some limitations: (i) the search process to compose the BP analyzed only the articles available in the scientific journals of the CAPES portal; (ii) only seven databases were used to carry out the research, not considering all existing databases; (iii) the study does not suggest a tool that addresses the identified research gaps. For future research, it is recommended the development of a performance evaluation that allows defining specific performance indicators involving the domains of specialization of ergonomics in the OHSMS.

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CONHECENDO OS MÉTODOS DE AVALIAÇÃO DA ERGONOMIA E DO DESEMPENHO DA SAÚDE OCUPACIONAL E SISTEMA DE GESTÃO DA SEGURANÇA

RESUMO: Considerando que o impacto mais significativo dos acidentes é sobre o próprio trabalhador, a ergonomia com sua abordagem sistêmica considerando os domínios de especialização pode contribuir para o planejamento e execução do SGSST, principalmente com a utilização de indicadores mais precisos para avaliar o desempenho do sistema. Este artigo tem como objetivo identificar e caracterizar as metodologias e indicadores utilizados para avaliar o SGSST por meio de um RSL. Para selecionar e analisar artigos sobre métodos de avaliação de OHSMS, o ProKnow-C foi aplicado, usando análises avançadas e sistêmicas, para identificar os tipos de métodos e o escopo e participação da organização. Como resultado, foi possível identificar que, nos 28 estudos analisados, foi utilizada uma abordagem normativa ou descritiva, genérica em 12 e específica em seis. Em contrapartida, o contexto era genérico em três estudos e específico em seis. Além disso, 28 trabalhos selecionados baseiam-se em indicadores genéricos, 18 utilizaram indicadores antecedentes e dez utilizaram a combinação de indicadores atrasados e antecedentes sem mencionar ou analisar os domínios de especialização da ergonomia. Da mesma forma, ficou evidente que não analisaram o contexto organizacional para definir os indicadores. Considera-se que os componentes da avaliação devem ser definidos com base no contexto da organização, auxiliando na identificação dos problemas e situações críticas que interferem nas atividades de gerenciamento de riscos. Assim, a organização pode definir como gerenciar os trabalhadores e contribuir para o seu bem-estar, permitindo melhorias contínuas no SGSST. Tudo isso sustenta a necessidade de desenvolver metodologias de avaliação a partir de indicadores específicos ao contexto da organização.

PALAVRAS-CHAVE: Ergonomia. Sistema de Gestão de Segurança e Saúde Ocupacional. Avaliação de desempenho. ProKnow-C.

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