

## USING QUANTITATIVE METHODS IN OCCUPATIONAL ACCIDENT RISK MANAGEMENT RESEARCH

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### ABSTRACT

**Highlights:** Damages to workers' health resulting from work accidents arise from risk factors in the work environment. The risk management of occupational accidents aims to avoid the losses caused by these factors. The knowledge produced in the last decades about prevention has challenged professionals to rethink management models. The scientific productions that employ quantitative methods in data analysis help identify strategies to be adopted by organizations. **Objective:** Identify the main quantitative methods in international scientific research on occupational accident risk management. **Design/Methodology/Approach:** This is a descriptive study with a quantitative approach, which seeks to add knowledge on the subject through a bibliometric survey of articles published between 2010 and 2019 in the Scopus, Science Direct, Web of Science, and Engineered Research databases. Descriptive statistics were used to analyze the data, especially absolute and relative frequency. **Results:** The results show that most publications use the techniques of descriptive statistics and reliability analysis, namely Crombach's Alpha. The research is in accordance with the concepts of Bradford's Law since many journals produced few scientific articles on the specific theme. To support the quantitative methods, the results point to the recurrence of scientific articles as a theoretical referential instead of the literature search, which explores books. **Research limitations:** The bibliographic portfolio investigated articles published in the four (4) selected databases between 2010 and 2019. It refers only to a part of the international production on the topic; therefore, the findings cannot be generalized. **Practical implications:** In practical terms, this study's results can help identify the characteristics of the scientific production on the subject, produce knowledge, contribute to the formation of networks of authors interested in and researching the subject, direct new studies, and provide support for methodological decisions for new research. **Originality/value:** Few scientific studies on occupational accident risk management have extensively analyzed international production with an emphasis on quantitative methods in data analysis.

**Keywords:** Quantitative methods; Risk management; Accidents at work; Bibliometric research.

## INTRODUCTION

Damages to workers' safety and health resulting from work accidents or occupational diseases stem from risk factors that create unhealthiness in the work environment. Occupational Accident Risk Management aims to avoid or minimize losses and damages caused by risk factors through preventive actions (Di Pace, 2015). For Mendes and Wünsch (2007), the knowledge produced in the last two decades about preventing occupational accidents has challenged occupational health and safety professionals to rethink management models.

Within this context, scientific productions employing quantitative methods in data analysis assist in the identification of strategies to be adopted, aiming at problem-solving through assertive actions. For Teixeira and Pacheco (2005), quantification may produce generalizations about human behavior from the application of tests with validity and reliability. Specifically, one can argue that the quantitative method's basic objective is to ensure maximum accuracy in the results obtained and avoid distortions of analysis and interpretation, providing a greater margin of confidence in the research (Gerhardt and Silveira, 2009).

This study aims to identify the use of quantitative methods in research on Occupational Accident Risk Management. To this end, a reflection was made about quantitative methods in articles published on this subject between 2010 and 2019 in the databases Scopus, Science Direct, Web of Science, and Engineered Research. This descriptive study uses a quantitative approach to add knowledge to the subject through bibliometric research.

This bibliometric study is justified by the fact that it is still a theme with ample gaps in knowledge. According to Skiba (1998), the dimension of the losses associated with occupational safety and health problems is significant, and the field of study in this area still presents ample research opportunities. The results of this study can help identify the characteristics of the scientific production on the subject, produce knowledge, and contribute to the formation of networks of authors interested in and researching the subject, in addition to directing new studies and providing support for methodological decisions in new surveys.

The interest in the employment of quantitative methods in research is not recent and covers areas such as marketing, highlighting the studies of Dallabona *et al.* (2010), Gouvêa *et al.* (2010), Gouvêa *et al.* (2011), Gouvêa *et al.* (2012), Gouvêa *et al.* (2013), Garcia *et al.* (2019), Smania *et al.* (2019), and Borges *et al.* (2019), and accounting (Silva *et al.*, 2010; Hosser *et al.*, 2018). To this, we add broader background issues, such as the fact that the wrong methodological choices in research constitute critical factors in research failures

in journals, as has been pointed out by studies, highlighting those of Espejo *et al.* (2013), Almeida (2014), and Falaster *et al.* (2016).

This article is structured in four sections besides this introduction. The following section addresses a brief theoretical foundation to support the research, in which the basic concepts of quantitative data analysis methods and the importance of Occupational Accident Risk Management are presented. The third section clarifies the methods adopted to conduct this research. The fourth section presents and analyzes the data, demonstrating the main results of the study. The last section deals with the final considerations, highlighting the theoretical contributions and making recommendations for future studies.

## THEORETICAL FOUNDATION

### Quantitative methods of data analysis

According to Hair Junior *et al.* (2005), quantitative methods in the human sciences are a support tool to assist in the organization of the observed phenomenon. When applied, they are a combination of mathematical, statistical, and computational sciences and are part of the organizational learning process in a scenario whereby organizational problems increasingly evolve in quantity, complexity, and skills (Siqueira, 2011).

For Richardson (2011), quantitative methods employ quantification both in the modalities of information collection and in their treatment using statistical techniques, from the most straightforward, such as percentage, average, and standard deviation, to the most complex, such as correlation coefficient, regression analysis, and multivariate analysis. Barbeta (2017) describes how quantitative data collection allows researchers to collect important information. However, for this, the data collected must be reliable. Data reliability is related to its collection and analysis processes.

The analysis and reliability method is the degree to which the measured result reflects the true result, i.e., how much a measure is free from the variance of random errors (Hayes, 1998). Among the reliability coefficients, Cronbach's alpha, which, according to Field (2009), was described in 1951 by Lee J. Cronbach, is an index used to measure the internal consistency type reliability of a scale, i.e., to assess the magnitude to which the items of an instrument are correlated.

According to Fávero and Belfiori (2017), descriptive statistics allow the researcher to better understand data behavior through tables, graphs, and summary measures, identifying trends, variability, and atypical values. Maroco (2003) asso-

ciates descriptive statistics with central tendency measures, dispersion measures, asymmetry and flatness measures, association measures, and graphical representations of results.

Hypothesis testing provides a method to verify whether sample data provide evidence to support or not a formulated hypothesis (Silva *et al.*, 2010). For Maroco (2003), tests that do not explicitly focus on population parameters are generically called non-parametric tests. However, those that generally require quantitative variables (measured on an interval or ratio scale) are the parametric tests.

According to Fávero and Belfiori (2017), analysis of variance is a dependency technique that compares the differences in means for two or more quantitative (metric) variables based on a set of categorical (non-metric) independent variables. Moreover, analysis of variance can determine several questions simultaneously (Freund and Simon, 2009).

Mingotti (2005) argues that the correlation technique aims to study the linear relations between two sets of variables. The application of this analysis summarizes the information of each set of response variables in linear combinations, seeking to maximize the correlation between the two sets. It is noteworthy that through its application, the strength of the existing relationship between two vectors of variables, the dependent and independent variables, is quantified (Fávero and Belfiori, 2017).

Regression analysis was defined by Tabachnick and Fidell (1996) as a set of statistical techniques that enables the evaluation of the relationship between a dependent variable and several independent variables. According to Malhotra (2001), it determines the relationship's structure from the mathematical equation that relates the independent and dependent variables. Hair Junior *et al.* (2005) highlight logistic regression analysis as a technique to identify the statistical differences between the scores of a set of variables for two or more previously defined groups.

Factor analysis is used to identify latent dimensions or factors that explain the correlations between a set of variables (Malhotra, 2001). According to Maroco (2003), the exploratory factor analysis technique was developed from Spearman's work in the early twentieth century on students' performance in several disciplines. Structural equation modeling is a generalized modeling technique used to test the validity of theoretical models that define hypothetical causal relationships between variables (Maroco, 2003).

Sensitivity analysis is used to determine the sensitivity of the results of a study or systematic review when the assumptions of how it was done are changed and to assess the degree of confidence of the results in situations of uncertain

decisions or assumptions about the data and results used (Clarke, 2001). Meta-analysis is a specific approach to synthesizing quantitative studies within a common topic involving the calculation of a special parameter, and its promise is to obtain some value from studies that do not meet the usual standards of significance on their own (Scriven, 2018).

Fuzzy logic supports modes of reasoning that are approximate rather than exact. Fuzzy system modeling and control are techniques for handling qualitative information rigorously (Gomide and Gudwin, 1994). Event tree analysis is a logical-inductive method to identify the various and possible sequences of events that may follow from an initial event that one wants to study. Its objective is to estimate whether the outcome of these arising events meets the desired outcome or not (Cantu, 2015).

### Occupational Accident Risk Management

Occupational safety and health can be understood as a discipline of the technological area focused on the study and application of methods for preventing accidents at work, occupational diseases, and other forms of harm to workers' health. Prevention is done by identifying and evaluating risk factors and workloads originating in the work process and implementing measures to eliminate or minimize these risk factors and loads (Mattos and Másculo, 2019).

Despite advances in occupational health and safety leading to measures to prevent injuries and illnesses in the workplace, challenges persist in many organizations (Väyrynen, 2015). The risks endanger the workforce, equipment, and work environment and affect the competitiveness and economic performance of industries and communities (Mohammadfam *et al.*, 2016).

The most common causes of occupational accidents include continuous changes in construction design, workplaces crowded with people and materials, inadequate working conditions, non-continuous or seasonal work, material handling, direct exposure to falls, slips, collisions, chemical exposure, electrical shock, and abrasion hazards (Cameron *et al.*, 2007; Grant, 2014). Gonzalez-Delgado *et al.* (2015) report that some measures are recommended to prevent occupational accidents, such as evaluation of the design of safety measures, elimination or substitution of risks, techniques, and measures related to work organization, and risk management implementation to protect workers in the workplace.

Given this, organizations often adopt either safety management systems or behavior-based systems approaches to managing their safety functions in an attempt to achieve performance excellence. Organizations typically prefer to

adopt one system over another, likely due to pragmatic (resource and implementation constraints) and philosophical reasons (Wachter and Yorio, 2014). For Fernandez and Perez (2014), the overall risk assessment process can be summarized as a process of hazard identification, risk analysis, and risk assessment, and a risk management framework is part of this process.

It is noteworthy that when a company invests in and develops Occupational Safety and Health actions, it aims to improve the quality of life of its largest capital, the human capital. Thus, the company creates a competitive differential, leading to increased productivity with reduced losses and, consequently, maximized profits (Franz *et al.*, 2008).

## METHOD

This study proposed bibliographic research to evaluate the use of quantitative methods in the data analysis of articles about Occupational Accident Risk Management in the last ten years. According to Martins and Theóphilo (2009), bibliographic research is necessary to conduct any scientific study since it seeks to explain a subject, theme, or problem based on references published in books, journals, websites, and Congress proceedings. For Guedes and Borschiver (2005), bibliometric research maps and generates different indicators for treating and managing information and knowledge, especially in scientific and technological information, communication, and productivity systems.

The approach method applied is classified as quantitative. According to Guimarães (2008), it is a set of scientifically formulated data analysis techniques that aid decision-making. As for the objective, the study qualifies as descriptive. Descriptive research is concerned with observing, recording, analyzing, classifying, and interpreting facts without the researcher's interference. Thus, the phenomena of the physical and human worlds are studied but are not manipulated by the researcher (Andrade, 2002).

As for the collection method, the study began with a documental survey of the scientific production in four databases: Scopus, Science Direct, Web of Science, and Engineered Research. The databases were selected based on the possibility of access through the Portal de Periódicos CAPES (Coordination for the Improvement of Higher Education Personnel), their alignment with the research proposal, and their importance to the area of knowledge.

The articles collected for the sample were selected using the following Boolean operations: "risk management" OR "occupational risk" AND "work accident" OR "occupational accident" in the titles, abstracts, and keywords of the articles, ranging from 2010 to 2019. **Figure 1** summarizes the

bibliographic portfolio selection process, demonstrating the filtering steps of the articles.

The surveys in the research base resulted in 259 scientific articles on the theme. After excluding repeated articles, the titles were read, and those aligned with the purpose of the study were analyzed, discarding the others and leaving 132 articles. Of these, the abstract and keywords were read in detail and those that did not present a full-text format or had a paywall were eliminated, even within the CAPES Portal de Periódicos, resulting in 91 articles.

In the final stage, we verified and segregated those using the quantitative approach to data analysis. Then, we proceeded to complete the reading of the remaining articles. We also eliminated those not integrally related to the theme of Occupational Accident Risk Management, generating the final bibliographic portfolio composed of 22 articles representing the scientific production to be explored in this research.

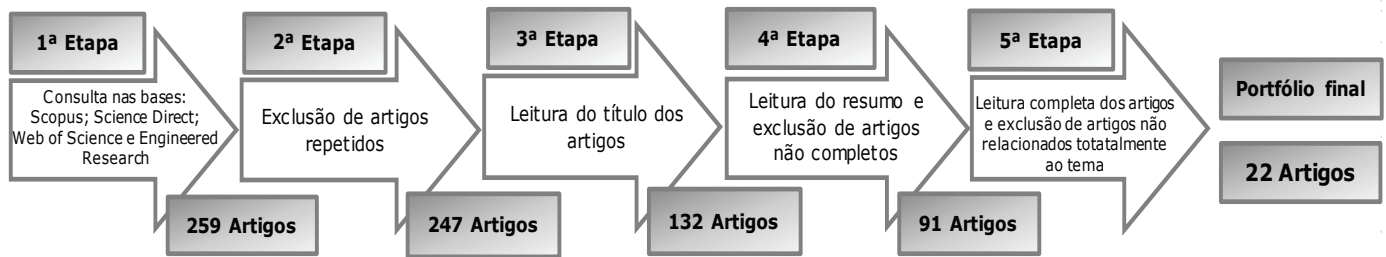
## RESULTS

The portfolio analysis considered the most relevant articles published on the theme and the identification of the quantitative methods employed in the research. We verified the measurement scales used in the composition of the information and the software used in the articles' data analysis. In addition, the reference bibliography of quantitative methods used as a source and support for the research studied was surveyed.

**Table 1** presents the bibliographic portfolio selected for the study, sorting through the number of citations in Google Scholar Citations in a query performed on October 07, 2019. It demonstrates the relative and cumulative frequency of citations received from the articles in relation to the portfolio.

It is found that among the research identified in the scope, the four (4) most relevant articles represent 50.7% of the citations regarding the total portfolio: the research by Wachter and Yorio (2014) had 158 citations; Cezar-Vaz *et al.* (2012) had 40 citations; Mohammadfam *et al.* (2016) had 36 citations; and Tziaferi *et al.* (2011) had 35 citations.

Seventeen countries were identified as the origins of research on the subject among the articles selected from the portfolio. It is noteworthy that three (3) countries accounted for 36.4% of the article publications in the analyzed period: the United States and Turkey with three (3) articles each and Iran with two (2) articles. The other countries, including Brazil, published only one paper each in the period analyzed. It was observed that several other countries are publishing studies on the subject, addressing quantitative methods in



**Figure 1.** Bibliographic portfolio selection process

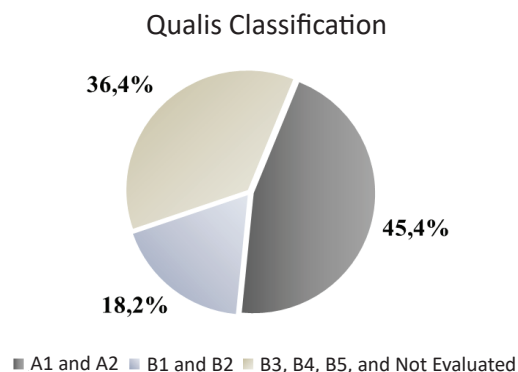
Legend: 1st Stage: Search in Scopus, Science Direct, Web of Science, and Engineered Research (259 Articles); 2nd Stage: Exclusion of repeated articles (247 Articles); 3rd Stage: Reading of the articles' titles (132 Articles); 4th Stage: Articles' abstract reading and exclusion of non-complete articles (91 Articles); 5th Stage: Full article reading and exclusion of articles not related to the topic; Final Portfolio; 22 Articles.

Source: The authors

data analysis, such as Mexico, India, Estonia, Malaysia, and Indonesia.

The scientific journals responsible for the publications on Occupational Accident Risk Management are shown in **Table 2**, considering the number of articles published and the Qualis classification of CAPES through the Sucupira platform from the 2013–2016 quadrennium.

The journals Safety and Health at Work (Qualis = A2), with three (3) articles, and Procedia Engineering (Qualis = B3), with two (2) articles published on the theme, stand out. The other journals published one (1) article each during this period. Verifying these results of bibliometric indicators, it is observed that the research analyzed in the portfolio is aligned with the concepts of Bredford's Law since many journals were found to produce few scientific articles on the specific theme. **Figure 2** shows the distribution of publications regarding the Qualis classification of the scientific journals.



**Figure 2.** Qualis classification of scientific journals

Source: The authors

It is noted that 45.4% of the scientific journals are classified as A1 and A2, demonstrating international relevance and ratifying the competence of the studies. The articles

classified between B1 and B2, also in a position of evidence in the scientific community, represented 18.2% of the portfolio. The others (B3, B4, B5, and Not Evaluated) correspond to 36.4% of the selected portfolio.

The quantitative methods employed in the data analyses of the selected articles are represented as shown in **Table 3**, as are the absolute and relative frequencies compared to the portfolio studies.

It was found that the quantitative method “descriptive statistics” stood out as the most used technique in the selected studies, present in the data analysis of 11 articles, representing 23.9% of the sample. This result follows the same trend as the findings of Dallabona *et al.* (2010) and Borges *et al.* (2019). The second quantitative method with the highest representativeness is reliability analysis (12.8%), used in six (6) surveys. Garcia *et al.* (2019) highlighted the use of this technique in their results, and it was the main method found in their findings in studies in the marketing theme.

Multiple regression analysis was identified as the third most representative method found in the studies (10.6%) and applied in five (5) articles. The most commonly used form of multiple regressions was the stepwise type. This is a type of strategy chosen for exploratory studies: the researcher, lacking a consistent theory about the phenomena studied, is interested in describing little-known relationships between variables and not in explaining them (Abbad and Torres, 2002).

The “non-parametric hypothesis testing” method had relevance to the research findings. Its applicability was identified in 8.5% of the articles. In this method, the main techniques used were the Mann-Whitney and chi-square types. The parametric hypothesis testing method was present in one (1) article in the selected portfolio.



**Table 1.** Selected bibliographic portfolio

No.	Title	n	%	fpa*
1	A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation (Wachter & Yorio, 2014)	158	29.8%	29.8%
2	Risk Perception and Occupational Accidents: A Study of Gas Station Workers in Southern Brazil (Cezar-Vaz et al., 2012)	40	7.5%	37.3%
3	Evaluation of the Quality of Occupational Health and Safety Management Systems Based on Key Performance Indicators in Certified Organizations (Mohammadfam et al., 2017)	36	6.8%	44.1%
4	Risk Assessment of Physical Hazards in Greek Hospitals Combining Staff's Perception (Tziaferi et al., 2011)	35	6.6%	50.7%
5	Analysis and Modeling of New and Emerging Occupational Risks in the Context of Advanced Manufacturing Processes (Fernández & Pérez, 2014)	32	6.0%	56.7%
6	Gender differences in the effect of weekly working hours on occupational injury risk in the United States working population (Wirtz et al., 2012)	27	5.1%	61.8%
7	Factors associated with fatal occupational accidents among Mexican workers: A national analysis (Gonzalez-Delgado et al., 2015)	24	4.5%	66.3%
8	Application of fuzzy DEMATEL method for analyzing occupational risks on construction sites (Seker and Zavadskas, 2017)	23	4.3%	70.6%
9	Risk Analysis in Construction Sites Using Fuzzy Reasoning and Fuzzy Analytic Hierarchy Process (Majumdera et al., 2013)	23	4.3%	75.0%
10	Individual-level and plant-level predictors of acute, traumatic occupational injuries in a manufacturing cohort (Souza et al., 2014)	19	3.6%	78.5%
11	A comparative study of objective and subjective assessment of occupational risk (Koradecka et al., 2015)	16	3.0%	81.5%
12	Safety and Health Practices and Injury Management in Manufacturing Industry (Taufek et al., 2016)	15	2.8%	84.4%
13	Occupational Health Policies on Risk Assessment in Japan (Horie, 2010)	14	2.6%	87.0%
14	Key factors contributing to accident severity rate in construction industry in Iran: A regression modelling approach (Soltanzadeh et al., 2016)	13	2.4%	89.5%
15	Perceived Safety Culture and Occupational Risk Factors among women in Metal Industries: A Study in Turkey (Akalpa et al., 2015)	12	2.3%	91.7%
16	The Organisational Environment-Behaviour Factor's Towards Safety Culture Development (Ismaila et al., 2012)	9	1.7%	93.4%
17	Formal Safety versus Real Safety: Quantitative and Qualitative Approaches to Safety Culture - Evidence from Estonia (Järvis et al., 2016)	9	1.7%	95.1%
18	Occupational health and safety management in construction sector - the cost of work accidents: (Buicaa, 2017)	7	1.3%	96.4%
19	Research on Ranking Evaluation Models of Safety Risk in Productive Enterprises based on the Perspective of Supervision (Hao et al., 2014)	7	1.3%	97.7%
20	Analysis and management of risks experienced in tunnel construction (Pamukcu, 2015)	6	1.1%	98.9%
21	Occupational health outcomes among international migrant workers: a systematic review and meta-analysis (Hargreaves et al., 2019)	3	0.6%	99.4%
22	Risk control analysis of a furniture production activities using hazard identification and risk assessment method (Indrawati et al., 2018)	3	0.6%	100.0%

\* Cumulative percentage frequency

Source: The authors

**Table 2.** scientific journals

Scientific Journal	Qualis	No. of Articles
Safety and Health at Work	A2	3
Procedia Engineering	B3	2
Accident Analysis & Prevention	A1	1
Scandinavian Journal of Work, Environment & Health	A1	1
Plos One	A1	1
Occupational and Environmental Medicine	A1	1
Lancet Global Health	A1	1
International Journal of Environmental Research and Public Health	A2	1
Sustainability Journal	B1	1
International Journal of Occupational Safety and Ergonomics	B1	1
Arh Hig Rada Toksikol	B1	1
Procedia Economic and Finance	B2	1
Procedia Technology Journal	B4	1
Procedia Manufacturing Journal	B5	1
Procedia - Social and Behavioral Sciences Journal	B5	1
EDP Sciences	B5	1
Proceedings of the Latvian Academy of Sciences	Not Evaluated	1
Quality-Access to Success	Not Evaluated	1
Acta Montanistica Slovaca	Not Evaluated	1

Source: The authors

**Table 3.** Quantitative methods identified in the survey

Quantitative method	Absolute Frequency	Relative Frequency
Descriptive Statistics	11	23.4%
Reliability analysis	6	12.8%
Multiple regression analysis	5	10.6%
Correlations	4	8.5%
Nonparametric hypothesis testing	4	8.5%
Logistic regression analysis	3	6.4%
Sensitivity Analysis	3	6.4%
Fuzzy logic	2	4.3%
Poisson regression analysis	2	4.3%
Confirmatory factor analysis	2	4.3%
Event tree analysis	1	2.1%
Analysis of variance	1	2.1%
Parametric hypothesis testing	1	2.1%
Structural equation modeling	1	2.1%
Meta-analysis	1	2.2%
Grand total	47	100.0%

Source: The authors

Another method of interest to the researchers in the data analysis was the correlations, as evidenced in four (4) studies. In this aspect, Spearman and Pearson correlation coefficients were identified.

It is noteworthy that other quantitative models for data evaluation were identified in the study. Overall, 15 different techniques were found in the scope of the articles selected on the theme. Besides those already described, the methods "sensitivity analysis," "logistic regression analysis," "fuzzy logic," and "confirmatory factor analysis" stand out.

It should be considered that there are still opportunities to explore the analysis of research data on the subject with greater academic rigor because the quantity and types of quantitative methods available can add to and contribute to the conclusion of the results, scientifically enriching the research.

Measurement in research consists of translating empirical facts, objects, and properties, or activities into numbers according to a set of rules: selecting observable empirical facts, developing a set of mapping rules, and applying these rules to each observation of that fact (Cooper and Schindler, 2011). The measurement scales used in the selected articles are presented in **Table 4**.

**Table 4.** Measurement scales used

Measurement Scale	Absolute Frequency	Relative Frequency
Likert 5 points	4	18.2%
Ordinal 5 points	4	18.2%
Interval 5 points	2	9.1%
Likert 7 points	2	9.1%
Interval 7 points	1	4,5%
Not Used	9	40.9%
Grand total	22	100.0%

Source: The authors

It can be seen that the Likert measurement scales, with five (5) points, and ordinal, with five (5) points, are the models with the highest recurrence used by researchers since together they represent 36.4% of the selected articles. When disregarding the nine (9) articles that did not use questionnaires in data collection without measurement scales, the proportion of articles that used such scales increased to 61.5% of the articles that opted for the methodology.

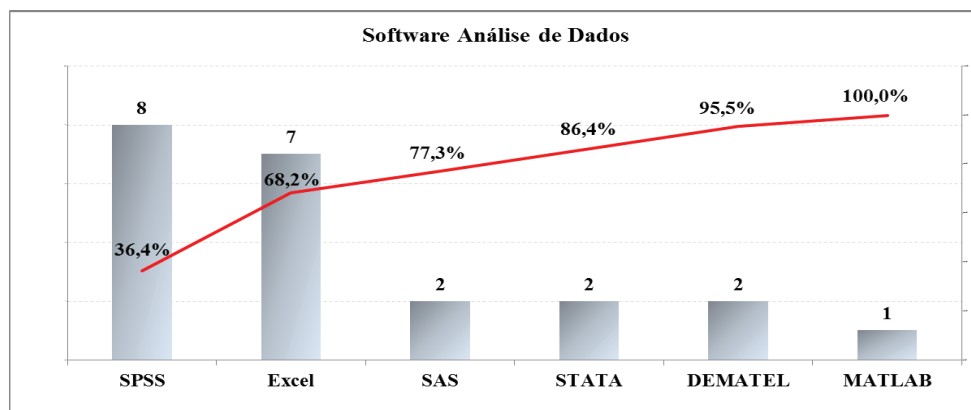
According to Silva *et al.* (2014), the most widely used and debated model among researchers was developed by Rensis Likert (1932) to measure attitudes in the context of behavioral sciences. The model consists of taking a construct and developing a set of statements related to its definition, for which respondents will indicate their degree of agreement. In the ordinal scale, the variable used to measure a given characteristic, besides relating to belonging to a class, also assumes that the different classes are ordered under a given criterion (Moraes, 2005). The interval scale was identified in two (2) studies. For Malhotra (2001), the interval scale is one in which numbers are used to classify objects in such a way that numerically equal distances represent equal distances in the measured characteristic.

Unlike the research of Garcia *et al.* (2019), Smania *et al.* (2019), and Borges *et al.* (2019), in which Likert measurement scales were the types exclusively found, researchers publishing on Occupational Accident Risk Management also resort to alternatives using scales, citing those of ordinal and interval types.

The employment of information technology in statistical analysis is a reality. In this context, relevant tools have emerged that facilitate researchers' understanding of concepts and data analysis for solving scientific problems. **Figure 3** identifies the software researchers used to support the data analysis of the selected articles in the portfolio.

SPSS (Statistical Package for the Social Sciences) software stands out as the main processing tool used by researchers, being present in the data analysis of eight (8) articles, representing 36.4% of the research on the theme. It is presented as a comprehensive product, a complete facilitator of data analysis, and, due to its excellent characteristics, has gained a prominent place in different areas, such as social sciences, humanities, and business, both in terms of use and research (Laureano and Botelho, 2017).

Descriptive statistics being the quantitative method most used by researchers, the Microsoft Excel spreadsheet data analysis tool from the Office suite was found in seven (7) studies. Smania *et al.* (2019) also found the recurrence of the Excel tool for data analysis in their findings. Levine (2008) considers Excel to be an electronic tool in which one can insert tables and graphs from a database, but its tools are not limited to this type of task as it has functions for various mathematical and statistical calculations, along with logic tests and others. Fávero and Belfiori (2017) demonstrate in a didactic way, through a manual, the use of some Excel tools in statistical data analysis.



**Figure 3.** Data analysis software used

Legend: 36.4% - SPSS; 68.2% - Excel; 77.3% - SAS; 86.4% - STATA; 95.5% - DEMATEL; 100.0% - MATLAB.

Source: The authors



Other data analysis software programs were used in the studies on the subject, including SAS (Statistical Analysis System), STATA (Statistical Software), and DEMATEL (Decision-Making Trial and Evaluation Laboratory). Each of these was used in two (2) articles. MATLAB (*MATrix LABORatory*) was used in only one (1) study.

Of the studies comprising the portfolio, only 36.4% of the research—eight (8) articles—bothered to list the supporting references that address the application of quantitative methods in data analysis. Overall, 15 references were identified, highlighting the research of Wachter and Yorio (2014), which used five (5) referential articles, accounting for 33.3% of the findings. Researchers who produce articles on Occupational Accident Risk Management do not worry about demonstrating the bibliographic reference as support in the application of quantitative methods of data analysis, thus generating gaps in knowledge due to the lack of evidence in the consulted bibliography.

**Table 5** shows the main sources of bibliographic references used as support in the studies, considering the quantitative methods employed in data analysis, ordering the five (05) most cited through Google Scholar.

Among the findings, the following bibliographic references stand out: The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical consideration by Baron and Kenny (1986) and Fuzzy sets by Zadeh (1965), with 86,647 and 83,426 citations, respectively, in Google Scholar. Also, with 45,819 citations, the reference A new look at the statistical model identification by Akaike (1974) stands out as one of the most significant in the research conducted.

As for the theoretical reference that addresses quantitative methods for data analysis, it was found that the explored research of the present work contemplates a higher amount as a source for citations from articles, unli-

ke the findings of Garcia, Soares, and Lima, 2019; Smania, Soares, and Lima, 2019; and Borges *et al.*, 2019, which found higher amounts of references based on book chapters.

## CONCLUSION

This research aimed to identify the quantitative methods employed in the data analysis of scientific productions addressing Occupational Accident Risk Management as a central theme. To meet the research objective, a bibliometric analysis was prepared of articles published in a temporal space between 2010 and 2019. In the study, we sought to identify articles, countries of origin that published on the theme, the quality of the journals, verify the quantitative methods used in the data analysis of the research, and present the main measurement scales, the most commonly used data analysis software, and the supporting bibliographic references for applying quantitative methods.

The research sample was composed of 22 articles aligned with the study theme. In terms of relevance of the publications about the number of citations in Google Scholar Citations, the most relevant articles are “A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation,” by Wachter and Yorio (2014), with 158 citations, followed by the article “Risk Perception and Occupational Accidents: A Study of Gas Station Workers in Southern Brazil,” by Cezar-Vaz *et al.* (2012), with 40 citations. Seventeen countries were identified as the origin of the research on the subject, observing a diversity of places that study the subject.

The quality of the scientific journals published stands out, and 45.4% are classified as A1 and A2 by the Qualis evaluation of CAPES. These are studies with international relevance. The articles classified as B1 and B2 represen-

**Table 5.** Main supporting bibliographic references

Reference	Number of Citations
Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical consideration. <i>Journal of Personality and Social Psychology</i> 51 (6), 1173–1182	86,647
Zadeh L A. (1965). Fuzzy sets. <i>Inform. Control.</i> ; 8:338-353.	83,426
Akaike H. A new look at the statistical model identification. <i>IEEE Trans Autom Control.</i> 1974; 19: 716–722	45,819
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Source: The authors; investigated in Google Scholar 10/11/2019

ted 18.2% of the portfolio, also with a clear position in the scientific community. With these results of bibliometric indicators, the research analyzed in the portfolio is aligned with the concepts of the Bradford Law since many journals produced few scientific articles on the specific theme.

Regarding the quantitative methods adopted in the research, most articles used the descriptive statistical technique, representing 23.4% of the portfolio. The recurrent use of descriptive statistics meets the literature analyzed. Also noteworthy is the use of reliability analysis (12.8%), namely Cronbach's alpha. Multiple regression analysis was also used (10.6%), as were correlations and non-parametric hypothesis tests, used in 8.5% of the studies. It should be considered that there are still opportunities to explore with greater academic rigor the data analysis since the quantity and types of quantitative methods available can contribute to the search for new conclusions, scientifically enriching the literature on Occupational Accident Risk Management.

Regarding the measurement scales adopted, the Likert scales, with five (5) points, and the ordinal scales, with five (5) points, are the most frequently used by researchers since together they represent 36.4% of the articles selected in the portfolio. However, nine (9) articles did not use questionnaires in data collection, therefore without using measurement scales.

SPSS (Statistical Package for the Social Sciences) was the main software used by the researchers in the data analysis of eight (8) articles, representing 36.4% of the research on the theme. Excel was the second choice among the data analysis tools used, as found in seven (7) studies. There are also other software options used, although less frequently.

Regarding the bibliographic references that support the quantitative methods, only 36.4% of the research (eight (8) articles) were concerned with evidencing the bibliography consulted. The researchers who produce on Occupational Accident Risk Management lack concern for demonstrating the bibliographic references that support the application of quantitative data analysis methods, thus generating knowledge gaps due to the lack of evidence in the bibliography consulted. Unlike the related surveys investigated, the researchers in Occupational Accident Risk Management tend to cite more articles than books.

As a theoretical contribution, this paper presents a portfolio of bibliographic research conducted in scientific and relevant databases, where the studies published from 2010 to 2019 on identifying the employment of quantita-

tive methods in articles with the theme of Occupational Accident Risk Management can be found. It also exposed the relevant journals that have published articles on the said topic. It presented the main quantitative data analysis methods, measurement scales, data analysis software, and supporting bibliographic references.

It is suggested that the present study be continued by expanding the databases to be consulted with the inclusion of databases such as Ebsco, Emerald, Wiley, and other scientific communication channels, such as the annals of events and banks of theses and dissertations.

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