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Occupational Health and Safety Management in the Port Sector: Literature review and research opportunities

Gestão de Saúde e Segurança do Trabalho no Setor Portuário: Revisão da Literatura e Oportunidades de Pesquisa

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ABSTRACT

The port sector is crucial to the global economy, and businesses in this sector face fierce competition, requiring services that enhance operational safety, intelligence, and environmental responsibility. However, the sector struggles to adopt innovations and faces challenges in worker health and safety. This research explores occupational health and safety management in the port sector through a comprehensive literature review of international publications. The aim is to highlight key aspects of this knowledge area and identify opportunities for future research. The Knowledge Development Process-Constructivist (ProKnow-C) was used to select the bibliographic portfolio (BP) and perform bibliometrics. The portfolio contains 27 scientific articles. The bibliometric highlights analyzed were: (i) relevant articles, (ii) distinguished authors, (iii) countries where the research was conducted, (iv) prominent journals, and (v) main keywords. The study emphasizes the main conclusions of the scientific articles, establishing our current understanding of the topic and identifying opportunities for further research.

Keywords: performance evaluation; ports; occupational health.

RESUMO

O setor portuário desempenha um papel fundamental na economia global e as empresas deste ramo competem intensamente, exigindo, cada vez mais, serviços que melhorem a segurança operacional, a inteligência e a responsabilidade ambiental. No entanto, o setor luta para adotar inovações e enfrenta desafios na saúde e segurança dos trabalhadores. Esta pesquisa explora a gestão da saúde e segurança ocupacional no setor portuário por meio de uma revisão da literatura de publicações internacionais. O objetivo é destacar aspectos-chave desta área de conhecimento e identificar oportunidades de pesquisa. O *ProKnow-C* foi utilizado para selecionar o portfólio bibliográfico e realizar a bibliometria. O portfólio contém 27 artigos científicos. Os destaques bibliométricos analisados foram: (i) artigos relevantes, (ii) autores de destaque, (iii) países onde a pesquisa foi realizada, (iv) periódicos proeminentes e (v) principais palavras-chave. O estudo enfatiza as principais conclusões dos artigos, estabelecendo nosso entendimento atual sobre o tema e identificando oportunidades para pesquisas futuras.

Palavras-chave: avaliação de desempenho; portos; saúde ocupacional.

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INTRODUCTION

The port sector plays a pivotal role in the global economy (Antao et al., 2016; Gul, 2020; Wang et al., 2023), acting as a crucial link between different modes of transportation in the process of goods commercialization (Del Giudice et al., 2021). Recent statistical data from the United Nations Conference on Trade and Development indicate that global merchandise exports reached a peak of $22.3 trillion in 2021 (UNCTAD, 2023), with maritime transport accounting for 90% of the cargo volume in world trade (World Economic Forum, 2019; Rambo et al., 2023).

In this context, companies in the port sector engage in intense competition to thrive in a highly volatile scenario, adopting economically accessible pricing policies and maintaining a high standard of service (Lu et al., 2009). This is reflected in services that demand increased safety, intelligence, and environmental responsibility in their operations (Del Giudice et al., 2021). However, the sector is considered complex in terms of introducing innovations (Beresford et al., 2012; Vanelslander et al., 2016) and hazardous concerning the health and safety of port workers (Gul, 2020; Corrigan et al., 2019; Motter & Santos, 2017; Lu & Kuo, 2016; Lu &Yang, 2010; Darbra & Casal, 2004).

Globally, it is estimated that 2.78 million deaths occur annually attributed to work. Occupational diseases account for the majority of mortality, representing 86.3% of the estimated total deaths, while fatal workplace accidents constitute the remaining 13.7% (Hämäläinen et al., 2017) Unfortunately, the port sector contributes to this lamentable statistic (Lu & Shang, 2005; Lu & Yang, 2010; Lu & Kuo, 2016; Cezar-Vaz et al., 2018; Corrigan et al., 2019). This scenario is dramatic, given that a significant portion of these occupational accidents and diseases could be preventable.

In light of this, proper management of health and safety issues in the port sector is essential and requires continuous monitoring of risks to identify vulnerabilities and implement control measures (Antao et al., 2016). This management can contribute to the reduction of workplace accidents and occupational diseases, posing a threat to people, the environment, and port assets (Wang et al., 2017), with the expected result being the promotion of worker well-being (Motter & Santos, 2017).

It is worth noting that companies often employ occupational health and safety management system approaches in an attempt to achieve performance excellence (Pallis, 2016). The diversity in management procedures is such that there are many suitable techniques for any given circumstance, and the choice has become more a matter of preference (Reniers et al., 2005) or due to pragmatic reasons (resource constraints and implementation) and philosophical reasons (Wachter & Yorio, 2014).

Considering the aforementioned, there is a need to deepen the understanding of health and safety management in the port sector, identifying the main characteristics of international literature on the subject. Who are the researchers who have dedicated efforts to these studies? What are the main journals that publish on the subject? What are the main findings and opportunities for future studies? In this scenario, the following research question guides this study: how has international literature addressed health and safety management in the port sector?

To answer this question, this research aims to explore the theme of health and safety management in the port sector through a literature review of international

publications, highlighting the key aspects of this knowledge area and identifying research opportunities according to the perceptions and limitations of the researchers. To achieve the research objective, the Knowledge Development Process Constructivist instrument (ProKnow-C) (Dutra et al., 2015; Ensslin et al., 2017; Ensslin et al. 2022) was employed. This is a structured methodology for the selection and analysis of scientific literature with a constructivist bias (Ensslin et al., 2023)

This research is justified by its importance and originality. It is important because it presents a structured and comprehensive procedure for the selection and analysis of literature that culminates in the identification of opportunities for future research. Furthermore, it addresses a subject that is intrinsically linked to worker health and, consequently, impacts society as a whole. It is original, as there are no international studies found that develop literature reviews on the topic from a constructivist perspective addressing the promotion of port worker health.

This research is structured into three sections, in addition to this introduction. The next section presents the research methodology used. In the third section, the data is presented and analyzed, revealing the main results. Finally, the last section discusses the conclusions, highlighting the contributions and recommendations for future research.

LITERATURE REVIEW

Port terminals are the locations where goods are loaded and unloaded onto ships, serving as key nodes in the maritime transport network (Lu & Yang, 2010; Wang et al., 2017), involving highly hazardous operations (Lu & Kuo, 2016; Molero et al., 2017; Motter & Santos, 2017). Given the complex nature of port work, employees are often exposed to various occupational risks that seriously threaten their health (Wang et al., 2023). According to the Occupational Safety and Health Administration - OSHA, in the United States, over 100 worker deaths and nearly 95,000 injuries occur each year due to improper equipment use in port terminal operations (Lu & Yang, 2010).

In the face of this calamity, over the past thirty years, public interest in the field of risk analysis has grown exponentially (Gul, 2020), with risk management emerging as an effective and comprehensive procedure that complements and integrates the overall management of almost all aspects of our lives (Fabiano et al., 2010). In this context, health, environmental, and physical infrastructure systems managers incorporate risk management into their decision-making processes (Pallis, 2016).

In the port environment, the situation is no different, as health and safety management assumes high importance (Wang et al., 2017; Gul, 2020), since accidents in industrial ports can result in injuries or fatalities, as well as severe environmental damage (Fabiano et al., 2010). According to Antao et al. (2016), due to the need to achieve strategic objectives regarding compliance with legislation, risk reduction, and environmental protection, one of the key elements for the success of management in any port authority is the use of performance indicators.

The International Maritime Organization has suggested a five-step process, which includes hazard identification, risk analysis, development of control measures to

reduce risks, cost-benefit analysis, and conclusions and recommendations (Zhang et al., 2016; Gul, 2020). According to Hanninen, Banda, and Kujala (2014), this occupational management aims to develop, plan, implement, and monitor accident prevention operations and risk minimization related to the safety of people, the environment, or assets.

Thus, the role of health and safety management in the port sector is the recognition of risks in different environmental work conditions and continuous monitoring of port work aiming for quality and the promotion of workers' well-being (Motter & Santos, 2017). According to Wang, Huang, and Wang (2023), appropriate management in health and safety aspects is essential to protect the occupational population against diseases and workplace accidents.

METHOD

To achieve the objectives of the research, the ProKnow-C was employed as an intervention instrument. The constructivist perspective of the method allows, through an interactive and structured process, the development of knowledge in researchers and the selection of a bibliographic portfolio (BP) aligned with the literature fragment to be explored (Dutra et al., 2015; Ensslin et al. 2017; Ensslin et al. 2022; Ensslin et al. 2023). The process is operationalized in four stages: (i) selection of the BP; (ii) bibliometric analysis; (iii) systemic analysis; and (iv) formulation of research questions and objectives (Dutra et al., 2015; Ensslin et al. 2023). For this research, the focus was on the first two stages of the process.

To initiate the selection of the BP, it is essential to first comprehend the theme for which knowledge is desired to be expanded. ProKnow-C recognizes that each topic has unique singularities, defined by the interpretations and restrictions attributed by the researcher to the theme (Ensslin et al. 2023). Therefore, the knowledge areas, named research axes, were determined, and a set of keywords that best represent each axis were identified, thus representing the theme to be explored. In this research, the defined axes and keywords are presented in Table 1.

Table 1 Research Axes and Keywords

#	Areas of Knowledge	Keywords
Axis 1	Performance evaluation	Performance; assessment; evaluation; measurement; management; appraisal
Axis 2	Occupational health and safety management	Safety management; safety assessment; occupational risk*; health risk*; safety and health; health and safety; occupational safety; occupational health; safety work; accident prevention; occupational accident

Axis 3	Port sector	port; seaport; harbor; Harbour

Source: Research data.

The intersection of the keyword sets for each axis created a Boolean expression representing the literature fragment delimited by the researchers. This expression was used to operationalize the search for scientific publications in the databases. The selected databases for the research were Scopus and Web of Science, chosen for their relevance within the scientific community and accessibility through the Periodicals Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES).

Next, the process of selecting scientific articles to form the Gross BP began. In this study, searches in the databases were conducted from August 21 to 28, 2023, using combinations of keywords defined by the research axis, restricted to the fields of article titles, keywords, and abstracts. The search was limited to scientific articles produced in the English language.

Conducting exhaustive searches for literature reviews, researchers explored various databases with overlapping content. To facilitate the filtering process, selected articles were imported into the EndNote Web bibliographic manager, resulting in 1567 articles, forming the portfolio of raw articles. At this stage, it was possible to identify and exclude redundant articles, those that appeared duplicated in the database, resulting in the elimination of 207 articles. This left 1360 articles for analysis regarding title alignment. After reading the titles of the articles, those in which the researcher did not identify adherence to the investigated knowledge area were eliminated from the process, leaving 76 articles with titles aligned with the research theme.

The next step involves verifying the level of scientific recognition of publications. In this case, the measurement was evidenced by the number of citations of each article in other scientific studies according to a search conducted on Google Scholar on September 1, 2023. After that, using Microsoft Office Excel, the articles were sorted in descending order according to the number of citations. Through mathematical properties to identify the representativeness of the articles, the relative and cumulative frequencies of each article in relation to received citations were calculated. The researcher established as a cut-off point for the permanence of selected articles a representativeness of at least 96% of the BP, resulting in 44 articles classified as having confirmed scientific relevance, thus forming Repository K (repository of non-repeated articles with aligned titles and recognized scientific relevance). The remaining 32 articles were sent to Repository P (repository of non-repeated articles with aligned titles and scientific recognition not yet confirmed).

Next, the abstracts of the articles from Repository K were read, and 21 publications with content aligned with the proposed theme were considered, forming Repository A (repository of non-repeated articles with aligned titles and abstracts and confirmed scientific recognition). Then, the authors of the articles from this repository

were identified, forming the BA repository (authors' repository), which consisted of 74 authors.

Continuing the article filtering process, the articles included in Repository P were analyzed to identify other research with the potential to be included in the BP. At this point, the articles from this repository were separated for analysis into two groups: those published before the year 2022, totaling 26 articles, and those published recently, between the years 2022 and 2023, resulting in 6 articles, some of which had no scientific recognition due to a short publication time but had the potential relevance for the research.

From the older articles in this repository, two were produced by authors contained in the authors' repository (BA), and after reading the abstracts, only one study was validated for alignment with the research. From the recent articles, after reading the abstracts, one was selected. The two resulting articles from the sum of those classified in the two groups formed Repository B (repository of non-repeated articles with potential scientific recognition). Considering the sum of the articles from Repositories A and B, 23 articles were obtained, which integrated Repository C (repository of non-repeated articles with aligned titles and abstracts and recognized scientific relevance). After a complete reading, all articles proved to be aligned with the research, forming the set of primary articles in the BP.

The last analysis stage, according to the ProKnow-C protocol, is the representativeness verification test, which aims to analyze the bibliographic references cited in the primary articles of the bibliographic portfolio. The references of the 23 selected articles were checked, exported to EndNote Web, totaling 1029 articles. After exclusion by filtering redundant articles, the titles were read, and those aligned with the theme were verified, resulting in 19 articles. The same process of verifying scientific recognition as in the previous stage was repeated, i.e., the articles were ranked in descending order in Microsoft Office Excel based on the citations received in a Google Scholar search conducted on September 15, 2023. In the analysis, considering 80% as the cut-off point for the permanence of the articles, 12 publications were selected. The last filtering process was the complete reading of the texts, resulting in the identification of 4 articles adhering to the theme and added to the 23 primary articles.

Thus, the BP for the theme, according to the perceptions and limitations of the researchers, consisted of 27 scientific articles, as demonstrated in Table 2.

Table 2 BP articles

#	Reference	#	Reference	#	Reference
1	Antao et al., 2016	**10**	Gul, 2020	**19**	Motter & Santos, 2017
2	Bauk et al., 2016	**11**	Hanninen et al., 2014	**20**	Niemela et al., 2002
3	Bloor et al., 2000	**12**	Kececi & Arslan, 2017	**21**	Pallis, 2016

4	Cezar-Vaz et al., 2016	**13**	Khandan et al., 2017	**22**	Reniers et al., 2005
5	Cezar-Vaz et al., 2018	**14**	Lu & Kuo, 2016	**23**	Vidmar & Perkovic, 2015
6	Chin & Debnath, 2009	**15**	Lu & Shang, 2005	**24**	Walters et al., 2020
7	Corrigan et al., 2019	**16**	Lu & Tsai, 2007	**25**	Wang et al., 2017
8	Darbra & Casal, 2004	**17**	Lu & Yang, 2010	**26**	Wang et al., 2023
9	Fabiano et al., 2010	**18**	Molero et al., 2017	**27**	Zhou et al., 2018

Source: Research data.

After completing the selection of the BP, the bibliometric and content analysis stage of the selected scientific articles began. Data analysis considered the highlights of the theme literature, including: (i) Relevant Articles: The relevance was determined by the number of citations on Google Scholar in a search conducted on September 1, 2023. (ii) Notable Authors: Notable authors were identified by checking authorship in the publications of the BP and its references. (iii) Research Locations: The countries where the research was conducted were identified. (iv) Prominent Journals: The prominence of journals was assessed regarding the quantity of articles published in each communication vehicle. (v) Predominant Keywords: The predominant keywords were evaluated by analyzing the relationship of co-occurrence among them. (vi) Main Findings: The main findings of the BP were determined by weighing the main conclusions of the articles. (vii) Research Opportunities: Research opportunities were identified by considering the main gaps identified by the authors of the BP in their studies.

These analyses collectively contribute to a comprehensive understanding of the literature fragment representing the theme of health and safety management in the port sector, in accordance with the researchers' perceptions and limitation

RESULTS

This section presents the research results obtained through bibliometric and content analysis, facilitated by the ProKnow-C intervention tool.

REVELANT ARTICLES

Based on the number of citations of the articles on Google Scholar, Table 3 shows the top five publications in order of scientific relevance. Together, they represent 47.5% of the citations of the articles that make up the selected BP.

Table 3 Most relevant articles in BP

	Reference	No. of Citations (Google Scholar) Sep 01, 2023	Relative Frequency	Cumulative Frequency
1	Lu & Yang, 2010	355	15,2%	15,2%
2	Darbra & Casal, 2004	254	10,9%	26,1%
3	Lu & Tsai, 2007	185	7,9%	34,1%
4	Reniers et al., 2005	167	7,2%	41,2%
5	Hanninen et al., 2014	146	6,3%	47,5%
6 - 27	Other articles	1224	52,5%	100%

Source: Research data.

The article with the highest scientific recognition in the BP is "Safety leadership and safety behavior in container terminal operations," published in 2010 in the journal Safety Science by researchers Chin-Shan Lu and Chung-Shan Yang. The authors emphasize the importance of leadership for effective safety management and investigate essential dimensions in the context of container terminal operations. Using research data collected from 336 respondents working for five major container terminal companies in Taiwan, they identified three main dimensions of safety leadership: (i) motivation for safety, (ii) safety policy, and (iii) safety concern. The findings suggest that motivation and safety concern positively affect the safety behavior of port workers, revealing positive associations between safety training and workers' safety behavior.

The second most relevant article in the BP is "Historical analysis of accidents in seaports," produced by Rosa-Mari Darbra and Joaquim Casal, published in Safety Science in 2004. The study aims to historically research accidents that occurred in seaports worldwide. The results demonstrate a significant increase in accident frequency over time, with 83% of accidents occurring in the last 20 years and 59% in the last decade (considering the research period). The study also lists frequent causes of accidents: falls (51%), fires (29%), explosions (17%), and gas clouds (3%). More than half of the accidents occurred during cargo loading and unloading operations.

Chin-Shan Lu and Chaur-Luh Tsai are the researchers of the third scientifically relevant article in the BP. The study titled "The effects of safety climate on vessel accidents in the container shipping context" was published in 2007 in the journal Accident Analysis and Prevention. The research empirically evaluated the influence of safety climate on accidents in the container shipping context. Six dimensions of safety climate were identified: (i) safety management practices, (ii) supervisor safety practices, (iii) safety attitude, (iv) safety training, (v) job safety, and (vi) co-worker safety practices. The study's results indicated that safety management practices and safety training significantly affect the incidence of accidents among port workers. Overall, the

research discusses theoretical and practical implications of the results for accident prevention in the context of container shipping.

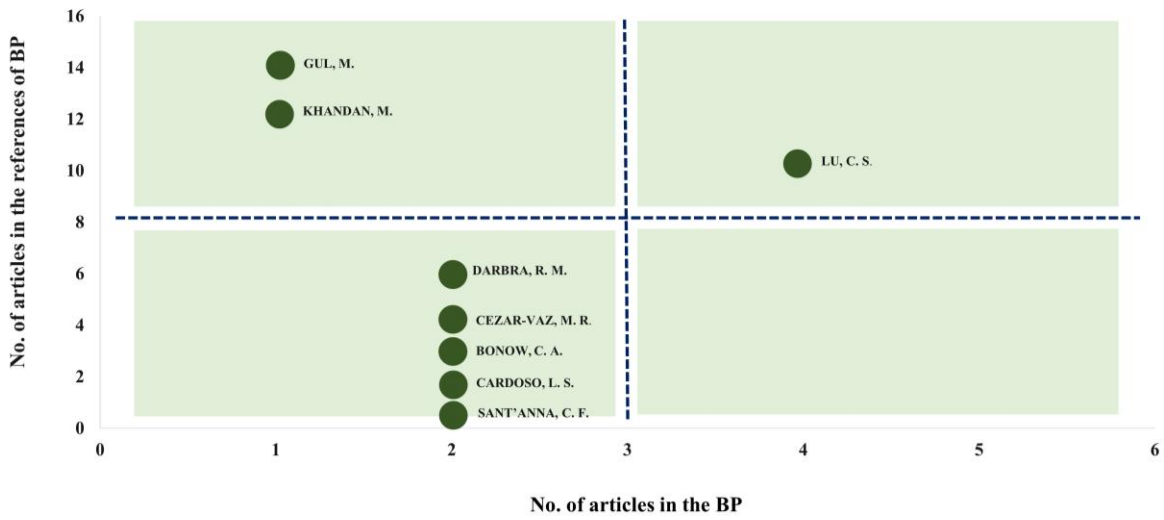
The fourth relevant article in the BP is "Developing an external domino accident Prevention framework: Hazwim," published in the Journal of Loss Prevention in the Process Industries in 2005. In this research, authors Reniers, Dullaert, Alec, and Soudana investigate the safety of severe accidents in the Antwerp port area in Belgium and propose a risk analysis technique called Hazwim. According to the authors, this tool integrates three complementary techniques into an effective standardized risk analysis framework for accident prevention. Hazwim's strengths include its comprehensiveness and cost-effectiveness, providing support to prevention managers and safety policymakers regarding accident prevention.

The fifth most cited article in the BP is "Bayesian network model of maritime safety management," developed by researchers Maria Hänninen, Osiris A. Valdez Banda, and Pentti Kujala, published in the journal Expert Systems with Applications in 2014. The study introduces a model of maritime safety management and its subareas. The Bayesian model was applied with expert perceptions and historical data. The findings suggest that, at the time of the research, the state of safety management for ships navigating Finnish waters could be improved. According to the model, a good computerized safety management system will enhance performance and support managers in safety-related decision-making.

NOTABLE AUTHORS

The 27 articles in the BP were authored by 74 individuals. To identify standout authors with significant scientific relevance and established expertise in the field over their professional careers, Figure 1 is presented.

Figure 1 Authors featured in BP and in BP references



Source: Research data.

Researcher Chin-Shan Lu stands out among the other authors, not only for being present in four articles that compose the BP (Lu & Shang, 2005; Lu & Tsai, 2007; Lu & Yang, 2010; Lu &Kuo, 2016), but also for having 10 articles published under his authorship identified in the bibliography of the portfolio. Lu is a professor in the Department of Transportation and Logistics Management at the National Yang Ming Chiao Tung University. He holds a Ph.D. in maritime studies and international transport from the University of Wales Cardiff, United Kingdom (1994-1997), and his area of expertise is port operations and management. In a survey conducted on September 30, 2023, he had 6,757 citations on Google Scholar, demonstrating his relevance to the scientific community.

It's worth highlighting researchers Mohammad Khandan and Muhammet Gul, who, even though they authored only one article in the BP, stood out and were present in 12 and 14 publications, respectively, in the BP references. Gul, with a Ph.D., works as an associate professor in the Department of Industrial Engineering at Munzur University, Turkey. His research interests include simulation modeling, healthcare system management, occupational safety, risk assessment, multicriteria decision-making, and Fuzzy sets. According to information from Google Scholar (September 30, 2023), his publications have been cited in 4,570 studies. Khandan, with a Master's in Ergonomics from Tehran University of Medical Sciences, focuses on understanding the influence of human factors in work. His scientific journey began in 2016, and his research has already been referenced in 663 studies.

COUNTRIES WHERE THE RESEARCH WAS CONDUCTED

A total of 15 countries were identified where research on the topic was conducted. The countries with more than one participation in the BP include China, Brazil, Turkey, Wales, Portugal, Spain, and Finland. Figure 2 illustrates the results.

Figure 2 Countries where the research was conducted

Source: Research data.

The Chinese port sector is the most prominently represented context in the BP, featured in 7 studies. Overall, these studies discuss various aspects influencing the results of health and safety performance in Chinese ports.

Lu and Yang (2010) address leadership performance and safety behavior in cargo terminals. Lu and Shang (2005) and Lu and Tsai (2007) aim to identify the effects of safety climate on accidents in the context of container transport. Luo and Kuo (2016) focus on the impact of job stress on the behavior of port workers. Zhou, Fu, and Xue (2018) research human and organizational factors in port accidents. Wang et al. (2017) explore occupational risks faced by port workers. Finally, Wang et al., (2023) study the influence of service time, professional category, and training on safety management.

It is noteworthy that according to the International Labour Organization (ILO), current statistics rank China as the highest globally in work-related fatalities, with a fatality rate of 6.9 deaths per 100,000 workers (ILOSTAT, 2023). Currently, scientific research related to the management of health and safety for workers is a prevailing trend in the country, reflecting a concern shared by many Chinese researchers.

PROMINET JOURNALS

In the BP, 16 journals were identified as responsible for publications on the studied theme. However, the prominent ones are the journals Safety Science and International Journal of Occupational Safety and Ergonomics, which, together, account for 48.1% of the scientific productions in the portfolio.

Table 4 Prominent journals

Journals	No. in BP	Relative Frequency	Cumulative Frequency
Safety Science	11	40,7%	40,7%
International Journal of Occupational Safety and Ergonomics	2	7,4%	48,1%
Other journals	1	51,9%	100%

Source: Research data.

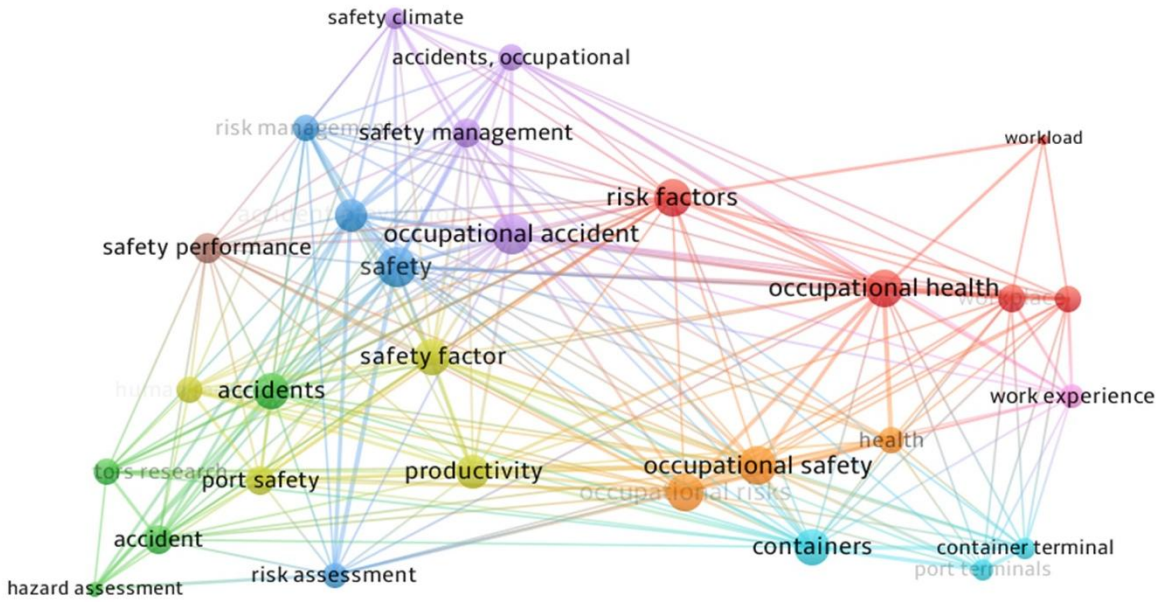
The journal with the highest representation in the BP is Safety Science, encompassing 11 out of the 27 selected articles, constituting 40.7% of the (Darbra & Casal, 2004; Chin & Debnath, 2009; Fabiano et al., 2010; Lu & Yang, 2010; Vidmar & Perkovic, 2015; Antao et al., 2016; Molero et al., 2017; Motter & Santos, 201; Kececi & Arslan, 2017; Corrigan et al., 2019; Walters et al., 2020). This journal positions itself as an international reference in the exploration of science and technology related to human safety. The scope of its research includes (i) physics and safety engineering, encompassing social, political, and organizational aspects; (ii) risk assessment, management, and communication; (iii) the effectiveness of safety control and management techniques; and (iv) standardization, legislation, monitoring, insurance, cost-related aspects, human behavior, and other issues relevant to human safety (Elsevier, 2023).

The International Journal of Occupational Safety and Ergonomics is represented in the BP by two scientific productions (Wang et al., 2017; Zhou et al., 2018). The primary objective of this journal is to establish a platform for presenting research findings in ergonomics and workplace health promotion that are pertinent to our diverse yet increasingly globalized world. Consequently, it aims to showcase how similar issues are studied and resolved in different parts of the world and how identical methods may yield diverse results (Taylor & Francis, 2023).

MAIN KEYWORDS

To analyze the main keywords in the articles, the network of occurrences in BP publications was examined. This network is determined by the co-occurrence relationship between two keywords in a document database where both appear together, either in the title, abstract, or in the keyword list itself (Van Eck & Waltman, 2018). Figure 3 illustrates the identified keywords in the BP. The size of the circles represents the frequency of keyword occurrences, and the closer they are, the stronger the association.

Figure 3 Keyword co-occurrences



Source: Research data.

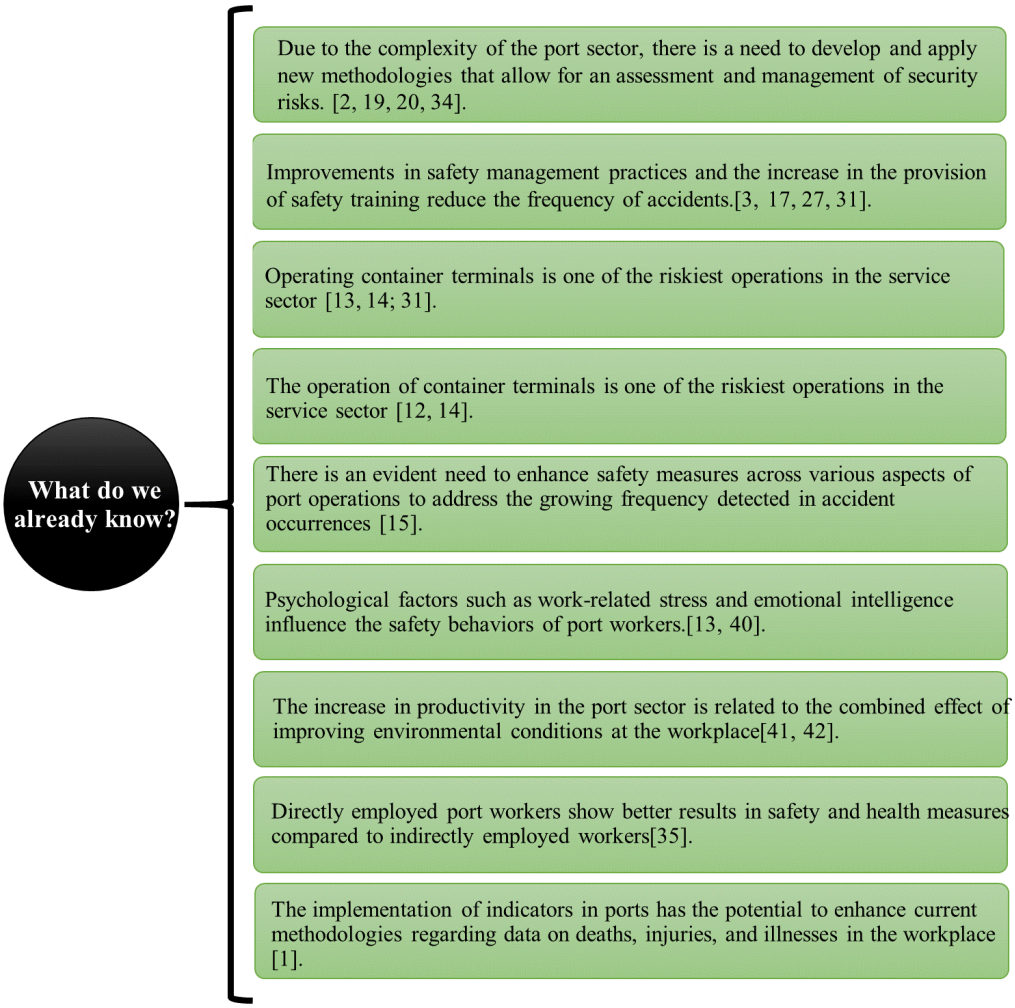
In the analysis of articles within the BP, a total of 108 keywords were identified. However, the focus for in-depth analysis was directed towards the top 30 keywords, which exhibited the most robust interconnections within this dataset. The outcomes led to the formation of 8 clusters, each revolving around the following keywords: (i) risk factors, (ii) occupational safety, (iii) occupational accidents, (iv) safety performance, (v) accidents, (vi) safety, (vii) safety factors, and (viii) containers.

It is important to highlight that, within the scope of the keywords found in the BP articles or their synonymous terms, these words align with those employed in the present study as search terms during the database search for articles. These identified keywords delineate the thematic focus of the BP in accordance with Zipf's Law, a conventional bibliometric principle (Vanti, 2002; Ensslin et al., 2022).

BP'S MAIN FINDINGS

Figure 4 presents a summary of the primary findings gleaned from the scientific articles in the BP, elucidating existing knowledge on occupational health and safety management within the port sector.

Figure 4 What do we already know?



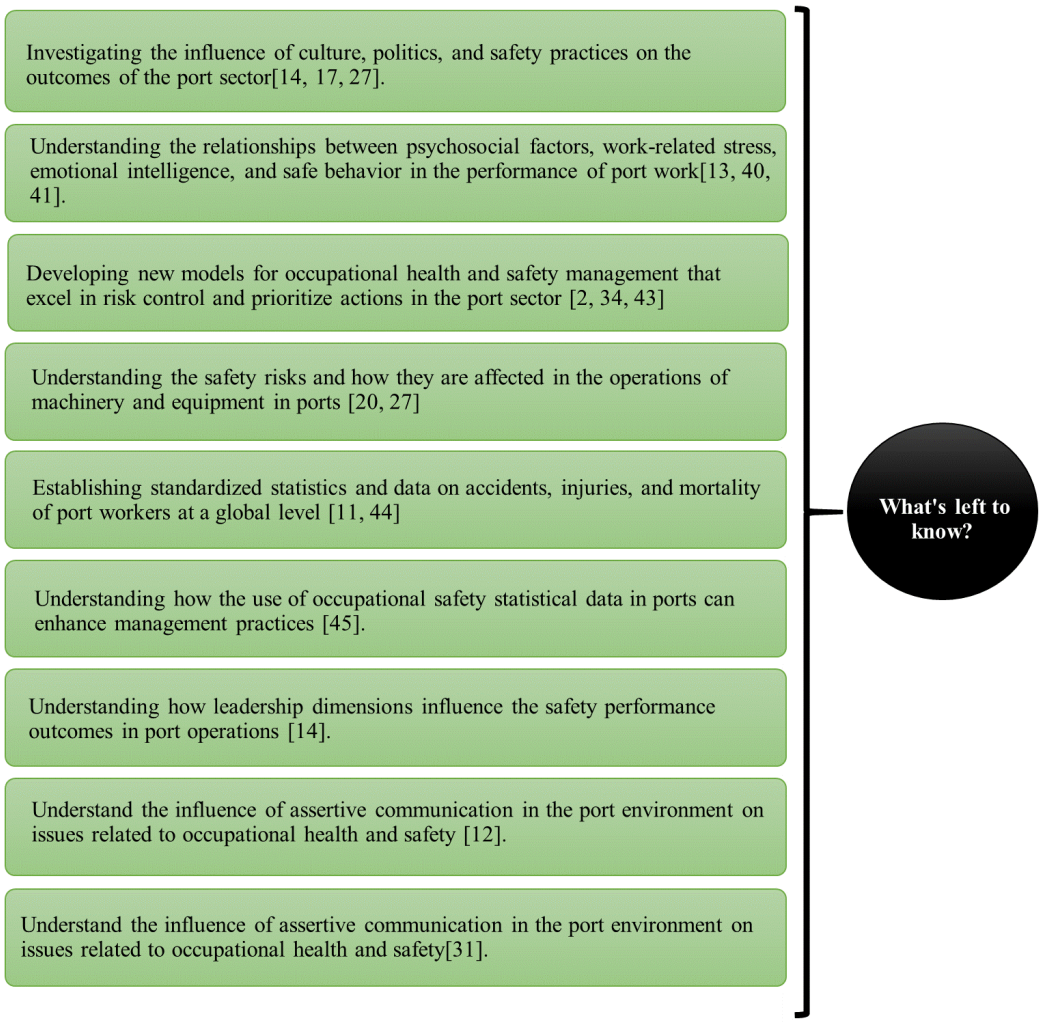
Source: Research data.

Upon examination of Figure 4, three recurring themes emerge in the conclusions of scientific articles within the BP. Firstly, evident in four studies, is the call for the development and exploration of novel methodologies to enhance the management of occupational health and safety (Pallis, 2016; Kececi & Arslan, 2017; Wang et al., 2017; Gul, 2020). Secondly, echoed in another four studies, is the affirmation of a positive correlation between promoting workplace safety practices and providing worker training, thereby influencing performance outcomes within the port sector (Lu & Shang, 2005; Lu & Tsai, 2007; Fabiano et al., 2010; Wang et al., 2023). Thirdly, a recurrent theme highlights the necessity to explore this topic, particularly within the port sector, with an emphasis on container terminal operations. These operations are recognized as among the most hazardous activities in the service industry, posing significant risks to the health of workers (Lu & Yang, 2010; Fabiano et al., 2010; Lu & Kuo, 2016).

RESEARCH OPPORTUNITIES

Figure 5 illustrates key research opportunities based on findings from scientific publications in the BP, highlighting areas yet to be explored in occupational health and safety management within the port sector

Figure 5 What's left to know?



Source: Research data.

In our analysis of the BP, several research opportunities addressing pertinent topics in health and safety management within the port sector were identified. Works by Lu and Shang (2005), Lu and Tsai (2007), and Lu and Yang (2010) underscore the importance of advancing cultural, policy, and safety practice issues, examining their impact on outcomes in the port sector. Despite these studies being over a decade old, recent articles within the BP continue to explore these subjects, responding to the identified opportunities (Cezar-Vaz et al., 2016;Lu & Kuo, 2016; Motter & Santos, 2017; Zhou et al., 2018; Corrigan et al., 2019; Gul, 2020; Walters et al., 2020).

Another literature gap requiring further investigation pertains to understanding psychosocial issues among port workers and their influence on job performance. This

theme extends beyond the port sector and encompasses various economic sectors. Human factors, job dissatisfaction, engagement level, and interpersonal relationships can contribute to job stress (Lu & Kuo, 2016), subsequently affecting safety behavior and outcomes (Zhou et al., 2018)

Research opportunities highlighted by Bauk, Schmeink, and Colomer (2016), Kececi, and Arslan (2017), and Gul (2020) emphasize the need for new models favoring health and safety management in the dynamic port sector. The complex nature of port operations demands systematic and proactive approaches to ensure worker safety. Recent research within the BP addresses this need, presenting new management methodologies that complement existing scientific literature.

Antão et al. (2016) propose a 'bottom-up' model for selecting indicators in port areas related to health, safety, occupational protection, and the environment. This model involves a comprehensive analysis, evaluating current indicators based on legislation, regulations, and industry stakeholder feedback.

Bauk, Schmeink, and Colomer (2016) introduce an RFID-based model to enhance the safety of port workers. Gul (2020) proposes a multicriteria decision-making model using a Fuzzy Analytic Hierarchy Process (FAHP) framework to assess health and occupational safety risks in ports. Hanninen, Banda, and Kujala (2014) present a maritime safety management model based on Bayesian networks, relating safety management to reported accidents and incidents.

Kececi and Arslan (2017) propose a SHARE root cause analysis technique for ship accidents, employing Fuzzy, SWOT, and AHP tools. Reniers et al. (2005) develop the Hazwim model, integrating various techniques into a standardized risk analysis framework for accident prevention in industrial port areas.

The information summarized in Figure 5, depicting what is yet to be known, underscores the primary research gaps identified in BP publications. This summary aids in characterizing scientific productions, fostering networks of authors interested in health and safety management in the port sector, and guiding and supporting new research in the field.

CONCLUSION

The objective of this research was to select and analyze, in bibliometric terms, a set of scientific articles addressing health and safety management in the port sector. The goal also involved identifying key research opportunities to guide future studies. The bibliographic portfolio (BP), representing a fragment of the international literature on the subject, consisted of 27 scientific publications selected using ProKnow-C.

From the bibliometric analysis, the articles with the highest scientific relevance were Lu and Yang (2010), Darbra and Casal (2004), Lu and Tsai (2007), Reniers et al. (2005), and Hanninen, Banda, and Kujala (2014). These five articles represent 47.5% of the citations in the research portfolio, conducted in September 2023 using Google Scholar. The highlighted author was researcher Chin-Shan Lu, whose studies are found in four articles in the portfolio and another 10 references.

China is the country where the majority of the research was conducted, being the setting for seven studies. Prominent journals were Safety Science and the International Journal of Occupational Safety and Ergonomics, especially the former, which served as the chosen communication channel for the publication of 13 articles, representing 48.1% of the research portfolio.

Key terms identified through the network of co-occurrences among the articles were: (i) risk factors; (ii) occupational safety; (iii) occupational accident; (iv) safety performance; (v) accidents; (vi) safety; (vii) safety factor; and (viii) containers.

The most recurrent findings in the conclusions of the articles in the portfolio were: (i) the development and application of new methodologies to improve health and safety management enhance the performance of the port sector; (ii) encouraging safety practices and the training of port workers favor sector results by reducing accidents and occupational diseases; and (iii) the port sector is highly risky, and improper management can compromise the health of port workers.

As a research agenda, the main gaps in the international literature found in the articles were: (i) the need to advance in cultural, policy, and safety practice issues and understand how these aspects influence the results of the port sector; (ii) exploring psychosocial issues involving port workers concerning their performance; and (iii) developing new models favoring health and safety management in the port sector.

In light of these results, it is added that due to the complexity of activities, the variety of exposed occupational risks, psychosocial factors of workers, and in line with alarming statistics, the port sector is considered a relevant risk to worker health. Consequently, its managers play a fundamental role in safety outcomes. The way they influence their subordinates affects the safe behavior of those who work there. Additionally, it is known that the introduction of new management models, new safety practices, employee training, and standardization of procedures are aspects that favor the reduction of the frequency of occupational accidents and illnesses.

By effectively integrating these health and safety management practices, ports can create a safer and more efficient environment. Reducing accidents and improving the well-being of workers not only meets ethical and regulatory obligations but also contributes to a more sustainable and productive port performance.

This article provides researchers with the necessary knowledge to initiate research on the fragment of literature on health and safety management in the port sector, as gaps have been identified that constitute research with the potential to contribute to the knowledge area. It also facilitates the formation of networks of authors researching the topic.

The research explored articles indexed in the Scopus and Web of Science databases, referring to a portion of international production on the topic. Therefore, the results found cannot be generalized, representing a limitation of this study. It is suggested to continue these studies by expanding the databases to include other communication channels, such as conference proceedings and thesis databases. Similarly, conducting a systemic analysis for the portfolio on the topic is suggested.

REFERENCES

Antão, P., Calderón, M., Puig, M., Michail, A., Wooldridge, C., & Darbra, R. M. (2016). Identification of occupational health, safety, security (OHSS) and environmental performance indicators in port areas. *Safety science*, *85*, 266-275.

Bauk, S., Schmeink, A., & Colomer, J. (2018). An RFID model for improving workers' safety at the seaport in transitional environment. *Transport*, *33*(2), 353-363.

Beresford, A., Pettit, S., Xu, Q., & Williams, S. (2012). A study of dry port development in China. *Maritime Economics & Logistics*, *14*, 73-98.

Bloor, M., Thomas, M., & Lane, T. (2000). Health risks in the global shipping industry: an overview. *Health, Risk & Society*, *2*(3), 329-340.

Cezar-Vaz, M. R., Bonow, C. A., Almeida, M. C. V. D., Sant'Anna, C. F., & Cardoso, L. S. (2016). Workload and associated factors: a study in maritime port in Brazil. *Revista latino-americana de enfermagem*, *24*, e2837.

Cezar-Vaz, M. R., Bonow, C. A., Xavier, D. M., Vaz, J. C., Cardoso, L. S., Mello, M. C. V. A. D., ... & Sant'Anna, C. F. (2018). Prevalence of low back pain and dorsalgia and associated factors among casual dockworkers. *International Journal of Environmental Research and Public Health*, *15*(10), 2310.

Chin, H. C., & Debnath, A. K. (2009). Modeling perceived collision risk in port water navigation. *Safety Science*, *47*(10), 1410-1416.

Corrigan, S., Kay, A., Ryan, M., Ward, M. E., & Brazil, B. (2019). Human factors and safety culture: Challenges and opportunities for the port environment. *Safety Science*, *119*, 252-265.

Darbra, R. M., & Casal, J. (2004). Historical analysis of accidents in seaports. *Safety science*, *42*(2), 85-98.

Del Giudice, M., Di Vaio, A., Hassan, R., & Palladino, R. (2022). Digitalization and new technologies for sustainable business models at the ship–port interface: A bibliometric analysis. *Maritime Policy & Management*, *49*(3), 410-446.

Dutra, A., Ripoll-Feliu, V. M., Fillol, A. G., Ensslin, S. R., & 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.

ELSEVIER. Safety Science. (2023) [cited 2023 Sep 16] Available from: https://www.sciencedirect.com/journal/safety-science

Ensslin, L., Ensslin, S. R., Dutra, A., Nunes, N. A., & Reis, C. (2017). BPM governance: a literature analysis of performance evaluation. *Business Process Management Journal*, *23*(1), 71-86.

Ensslin, L., Gonçalves, A., Dutra, A., & Ensslin, S. R. Gestão de Riscos de Acidentes de Trabalho na Indústria da Construção Civil: Revisão Bibliográfica. *Gestão e Desenvolvimento em Revista*, *9*(1), 59-80.

Ensslin, L., Gonçalves, A., Ensslin, S. R., & Dutra, A. (2023). Bibliometric and systemic review of the state of the art of occupational risk management in the construction industry. International Journal of Occupational Safety and Ergonomics, 29(3), 1107-1120.

Fabiano, B., Currò, F., Reverberi, A. P., & Pastorino, R. (2010). Port safety and the container revolution: A statistical study on human factor and occupational accidents over the long period. Safety science, 48(8), 980-990.

Gul, M. (2020). A fuzzy-based occupational health and safety risk assessment framework and a case study in an international port authority. *Journal of Marine Engineering & Technology*, *19*(4), 161-175.

Hänninen, M., Banda, O. A. V., & Kujala, P. (2014). Bayesian network model of maritime safety management. *Expert Systems with Applications*, *41*(17), 7837-7846.

Härmälinen P, Takala J, Kiat TB. (2017). Global estimates of occupational accidents and work-related illnesses 2017. *World*. 2017; 3-4.

ILO. International Labor Organization. (2023) [cited 2023 Sep 20] Available from: https://ilostat.ilo.org/topics/safety-and-health-at-work

Kececi, T., & Arslan, O. (2017). SHARE technique: A novel approach to root cause analysis of ship accidents. *Safety science*, *96*, 1-21.

Khandan, M., Koohpaei, A., Kohansal Aghchay, M., Ebrahimi, M. H., Khammar, A., Arsang Jang, S., & Poursadeghiyan, M. (2017). Assessing the factors predicting work-related musculoskeletal disorders among Iranian port's personnel using regression model. *Iranian Rehabilitation Journal*, *15*(4), 309-316.

Lu, C. S., & Kuo, S. Y. (2016). The effect of job stress on self-reported safety behaviour in container terminal operations: The moderating role of emotional intelligence. Transportation research part F: traffic psychology and behaviour, 37, 10-26.

Lu, C. S., Lin, C. C., & Tu, C. J. (2009). Corporate social responsibility and organizational performance in container shipping. *International Journal of Logistics: Research and Applications*, *12*(2), 119-132.

Lu, C. S., & Shang, K. C. (2005). An empirical investigation of safety climate in container terminal operators. Journal of safety Research, 36(3), 297-308.

Lu, C. S., & Tsai, C. L. (2008). The effects of safety climate on vessel accidents in the container shipping context. *Accident Analysis & Prevention*, *40*(2), 594-601.

Lu, C. S., & Yang, C. S. (2010). Safety leadership and safety behavior in container terminal operations. *Safety science*, *48*(2), 123-134.

Molero, G. D., Santarremigia, F. E., Aragonés-Beltrán, P., & Pastor-Ferrando, J. P. (2017). Total safety by design: Increased safety and operability of supply chain of inland terminals for containers with dangerous goods. *Safety science*, *100*, 168-182.

Motter, A. A., & Santos, M. (2017). The importance of communication for the maintenance of health and safety in work operations in ports. *Safety science*, *96*, 117-120.

Niemelä, R., Rautio, S., Hannula, M., & Reijula, K. (2002). Work environment effects on labor productivity: an intervention study in a storage building. *American journal of industrial medicine*, *42*(4), 328-335.

Pallis, P. L. (2017). Port risk management in container terminals. *Transportation research procedia*, *25*, 4411-4421.

Rambo, M. A., Ensslin, L., Dutra, A., & Ensslin, S. (2023). Using the constructivist multi-criteria decision aid model (MCDA-C) to supporting the planning of the creation of a quality seal for cargo handling for ports of Santa Catarina. *World Review of Intermodal Transportation Research*, *11*(3), 280-304.

Reniers, G. L., Dullaert, W., Ale, B. J. M., & Soudan, K. (2005). Developing an external domino accident prevention framework: Hazwim. *Journal of Loss Prevention in the process industries*, *18*(3), 127-138.

TAYLOR & FRANCIS. International Journal of Occupational Safety and Ergonomics. (2023). [cited 2023 Sep 16] Available from: https://www.tandfonline.com/journals/tose20

UNCTAD. United Nations Conference on Trade and Development. (2023). [cited 2023 Sep 12] Available from: https://unctadstat.unctad.org/EN/Infographics.html?theme=trademerch-check

Van Eck, N. J., & Waltman, L. (2018). Manual for VOSviewer version 1.6. 8. *CWTS meaningful metrics. Universiteit Leiden*.

Vanelslander, T., Carlan, V., & Sys, C. (2016). Innovation among seaport operators: A QCA approach for determining success conditions. Innovation among seaport operators: a QCA approach for determining success conditions, 291-314.

Vanti, N. A. P. (2002). Da bibliometria à webometria: uma exploração conceitual dos mecanismos utilizados para medir o registro da informação e a difusão do conhecimento. *Ciência da Informação*, *31*, 369-379.

Vidmar, P., & Perkovič, M. (2015). Methodological approach for safety assessment of cruise ship in port. *Safety science*, *80*, 189-200.

Wachter, J. K., & Yorio, P. L. (2014). A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation. *Accident Analysis & Prevention*, *68*, 117-130.

Walters, D., Wadsworth, E., & Bhattacharya, S. (2020). What about the workers?—Experiences of arrangements for safety and health in global container terminals. Safety Science, 121, 474-484.

Wang, J., Mo, C., Sheng, Q., Huang, Y., Lin, D., Liang, Y., & Zhang, N. (2023). Association of length of service and job category with occupational health literacy of port employees in Shenzhen, China. *BMC Public Health*, *23*(1), 1-10.

Wang, Y., Zhan, S., Liu, Y., & Li, Y. (2017). Occupational hazards to health of port workers. *International Journal of Occupational Safety and Ergonomics*, *23*(4), 584-588.

World Economic Forum. Here are the 20 Busiest Ports on the Planet. (2019). [cited 2023 Sep 15] Available from: https://www.weforum.org/agenda/2019/02/visualizing-the-world-s-busiest-ports

Zhou, L., Fu, G., & Xue, Y. (2018). Human and organizational factors in Chinese hazardous chemical accidents: A case study of the '8.12'Tianjin Port fire and explosion using the HFACS-HC. *International journal of occupational safety and ergonomics*, *24*(3), 329-340.