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Original Research Article

Publication Trends and Thematic Evolution of 45 Years (1975-2020) Research on Safety Communication

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Abstract: Safety at work is a global concern because accidents and injuries are the results of unsafe behaviour. Safety communication at the workplace is, therefore, necessary to improve safety. This study aims to analyse publication trends and thematic evolution in safety communication at the workplace over 45 years from 1975 to 2020. The review uses the Scopus database and various bibliometric indicators such as publication trends, citations, and authors' keywords. Graphical visualisation of bibliometric indicators using VOSviewer is also presented. SciMAT was used to inspect the thematic evolution of safety communication research at the workplace. Safety communication research has fluctuated with less than 50 publications annually. This review is interested in several themes and dimensions in changes and evolution of safety communication. Essential themes in the first period (2006-2010) were "occupational-accidents". The "questionnaires", "safety-behavior", and "risk-factor" themes became the most significant number of publications and citations during the second period (2011-2015). "Organisational-culture" was the high number of publications in the motor themes during the third period of studies (2016-2020). These five themes may be useful as a benchmark for occupational safety and health researchers and professionals focused on the art of safety communication at the workplace.

Keywords: Publication trends, thematic evolution, safety communication, Scopus database.

INTRODUCTION

Safety at the workplace is a global concern as accidents and injuries caused by unsafe behaviour have dominated all employment sectors [1]. Though safety at the workplace has improved, the International Labour Organization (ILO) reported that 2.3 million workers worldwide had died every year from work-related injuries, corresponding to more than 6,000 deaths daily [2]. Therefore, it is designated that safety communication effectiveness plays a significant role in improving workplace safety [3, 4]. It is also specified that safety communication is crucial in managing efficient and effective workplace safety and health. Recently, the importance of effective safety communication at the workplace is a widely researched topic in various employment sectors [3, 5].

There are two different kinds of safety communication; formal and informal. A formal safety communication was established using information exchange by written documents and management scopes such as safety training and toolbox discussions [6]. Toolbox discussions are referred to as pre-work meetings and used to raise awareness of safety issues and conditions at the workplace [5]. Top management also plays a vital role in promoting safety initiatives to build a healthy workplace safety culture [7]. Safety initiatives such as conducting a hazard analysis, promoting safety training, and reporting accidents help alleviate exposure to work-related risks [6]. Otherwise, informal safety communication is a spontaneous conversation and announcement [5]. The goal of informal safety communication could be for a

worker to remind another worker about previous accidents that lead to health-related injuries [5-7].

When it comes to the construction sector, safety and health are considered significant concern in many countries [8]. This is because the construction industry is growing fast, profitable, and becomes one of the largest sectors that supports a country's economy [3, 4]. Nevertheless, the construction industry is a very high-risk industry, with production being prioritised over safety in daily on-site communication [3, 4, 9, 10, 11]. Workers' cultures in the construction industry also tended to be informal and communicate little toward safety [9]. Abas et al. found that 2,822 casual occupational injuries occurred in Malaysia, with an average annual incidence of 9.2 fatal job-related injuries per 100,000 workers [10]. Recent data from the Department of Occupational Safety and Health (DOSH) displays that 1,116 work-related accidents occurred throughout 2011 to 2016 and that 37.85% of these accidents resulted in non-permanent disability, permanent disability, and death [11].

Apart from organisational factors that affect safety performance, individual performance is also influenced by various elements in their working environment, such as communication [12, 13]. It is specified that the quality of supervisor communication about safety contributes to safety outcomes, above and beyond measures of both group-level and organisation-level safety climate [14]. Besides, positive safety communication is essential contributors to improving workplace safety because workers were sufficiently aware of human factors and safety rules that influenced their performance [15]. Therefore, a supervisor must play a key role in encouraging safe working practices by encouraging safety management and motivating team members to create safety culture perceptions and safety behaviour [17].

Additionally, team communication improves awareness of safety hazards and any safety issues, which will lead to organisational losses [18]. Supervisors and managers who express their opinions and requirements to the workers are aware of the conflicts between production and safety goals. As a part of the workplace environment, supervisor-worker communication is influenced by different factors [17, 18]. Therefore, improving safety communication is an essential tool for decreasing workplace injuries [19]. It is due to a lot of research showing that training is not always practical [20]. Differentiators between low and high accident rate teams are the frequency and communication method [5].

Safety communication is key to creating a safe work environment. Workers, therefore, need to be informed about hazards, unsafe practices, and risk behaviours. Safety communication is generally broad in scope and depends on the nature of specific organisations. Previous researchers have researched safety communication in broad spectra and context such as patient safety [21], road safety [22], drug safety [23], public safety [24], and vehicular safety [25]. It is indispensable to scrutinise safety communication in a specific context to avoid misunderstandings about the core ideas. Thus, this bibliometric review focuses on safety communication at the workplace with a robust search keywords strategy. It is purposely conducted to analyse precise publication trends and thematic evolution of safety communication at the workplace.

MATERIALS AND METHODS

The number of publications in any study area contributed to scholars' influential arguments to obtain relevant data [26]. Thus, bibliometric analysis became a common research trend. In the past, the bibliometric study was a useful mathematical and statistical method to analyse books and other mediums of communication [27]. Bibliometric analysis is currently used to obtain information on publishing patterns, the quantity and content of publications, and analyse author details, keyword frequencies, and citations [28, 29]. The publication trends were examined based on VOSviewer software developed by Van Eck and Waltman [30]. VOSviewer applied visual elements based on mapping techniques, which converts data related to Comma Separated Values (CSV) format into diagrams or clusters [30, 31]. Mapping techniques help analyse information on authors, locations, institutions, citations, co-citations, and other refining aspects [32]. Thematic analysis in this study is conducted using SciMAT to discover thematic and conceptual development of safety communication research at the workplace [33]. This study was interested in studying the thematic evolution of safety communication starting in the post-2005 publications. The timeframes were divided into three periods; the first period (2006-2010), the second period (2011-2015), and the third period (2016-2020). The explanation of the evolution comes from 4 different themes by Cobo et al. [33], as shown in Table 1.

Table 1 - The simplified of four themes in the strategic diagram [33]

Themes	Position	Explanation
Motor themes	Upper-right quadrant (first quadrant)	• Well established and essential for the organisation of a field of research • Centrality and density is very high • These themes are related to each other in a similarly broad scope
Highly developed and isolated themes	Upper-left quadrant (second quadrant)	• Well developed internal ties but inconsequential external ties • Only marginal importance for the field • These themes emphasise the necessary specialist and peripheral role.
Emerging or declining themes	Lower-left quadrant (third quadrant)	• Weakly developed and marginal • Being low density and low centrality • These themes representing either emerging or disappearing
Basic and transversal themes	Lower-right (fourth quadrant)	• Essential for a research field but are not developed • These themes depict transversal, general and basic

The bibliometrics data was retrieved using the Scopus search engine on January 2, 2021. The Scopus database was selected because it has extensive documents compared to the Web of Science and Pubmed [34] and has also been frequently cited in previous studies [35]. This study is aimed to discuss bibliometric on safety communication at the workplace. As a result, the retrieved data was organised under each robust keyword "Safety Communication" AND "workplace" based on the TITLE-ABS-KEY. The result of retrieved data produces 324 publications from 1975 to 2020. Out of the 324 publications, 237 were journaling articles from various outlets, 57 were conference papers, and less than 20 other publications such as books, book series, and trade journals. A total of 313 publications were written in English and less than five in other languages such as German, Chinese, and Italian.

RESULTS AND DISCUSSION

Global Trend of Publications, Leading Countries, and Distribution of Institutions

The number of publications is an essential element in the development of any research field. Fig. 1 shows the number of safety communication research at the workplace between 1975 and 2020. The publications increased by five academic works in 2004 and decreased slightly to one in 2005. However, starting in 2006, the number of publications increased by at least five, with the number of publications increased by 40 in 2020. During the first and second decades of publication, the number of published documents stagnated by one publication (1975-1999). It is worth noting that the number of publications began to increase with a significant number of publications in 2010, with 22 publications. The number of publications in 2011 and 2012 fell to below 20, with 11 and 12 publications, respectively.

The number of publications has continued to rise with 21 publications in 2013 and is undergoing a fluctuating cycle until 2020. However, the number of publications has been in a steady phase, with more than 20 publications annually. Publications rose rapidly in 2014 and 2015. It is indicated that the increase in publications is mainly due to an increasing interest in safety communications between 2014 and 2015. This is due to the risk-recognition incentive programs and workplace safety programs that engage workers through a reliable and consistent communication infrastructure [36]. It has become a beneficial method for identifying human-related issues and promoting accident prevention and improving safety at work. Furthermore, the number of researchers worldwide and the increased number of safety communications at the workplace in the Scopus database have undoubtedly affected the number of publications. By witnessing the exponential growth observed in safety communication research between 2014 and 2020, it can be interpreted that this area of research is relevant and reputable.

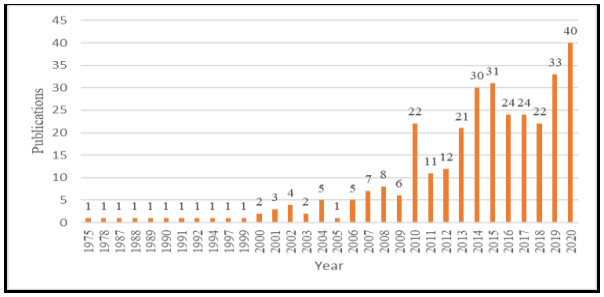

Fig-1: Global trend of publications

Scholars from 11 countries have contributed to disseminating safety communication research with at least ten publications, as indicated in Fig. 2. The top three on the list are the United States, with 99 publications, followed by Australia (30 publications) and the United Kingdom (26 publications). Results indicate that developed countries have dominated safety communication research publications for more than four decades. Increased safety communication research by developed countries resulted from increased workplace injury and accident costs, loss of productivity, and unnecessary distress for workers and their families [37]. Conversely, when safety hazards are not communicated and responded to, risky behaviours and the likelihood of injury may increase [38].

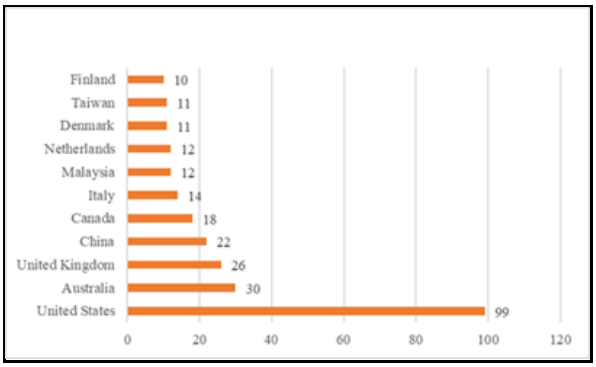

Fig-2: The leading countries with ten publications

The role of institutions in the publication of safety communication research is essential for disseminating safety communication at the workplace. The ranking results of the leading countries were based on at least four publications. Fig. 3 showed that the RMIT University and the Det Nationale Forsknings Center for Arbejdsmiljøthe had the highest number of publications with seven publications, respectively. The information in Fig. 3 also indicated that academics and professional experts had been actively engaged in safety communication research for 45 years and played an essential role in publications.

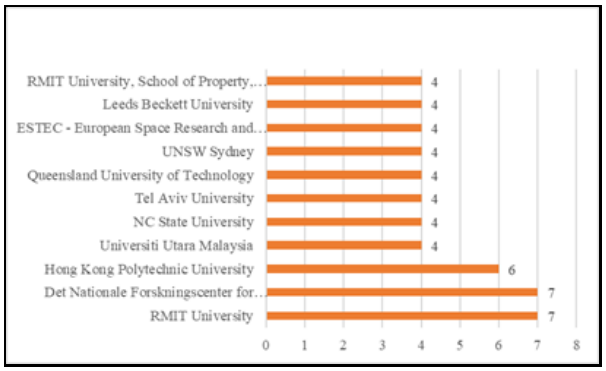

Fig-3: The distribution of institutions

Contribution of Research Areas, Preferred Outlets, and References Analysis

The contribution of research areas showed the empirical assortment of research categories. An analysis of the research areas of 324 publications was divided into 27 categories. As seen in Fig. 4, the top five research areas are led by Engineering (155 publications), Medicine (109 publications), Social Sciences (75 publications), Computer Science (46 publications), and Business, Management and Accounting (40 publications). Engineering became a top-notch area because new technologies, substances and work processes have made the workplace and the workforce change [39]. Thus, understanding the impact of new technologies on occupational safety and health is both a challenge and an opportunity.

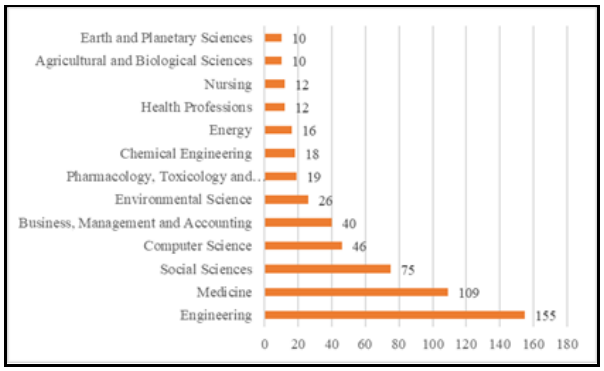

Fig-4: The contribution of research areas

Fig. 5 depicts 11 publications outlets with at least three publications. The top on the list was Safety Science with 16 publications. Next, was the Journal of Safety Research in the second rank (8 publications) and Accident Analysis and Prevention in the third rank with a frequency of seven publications. This phenomenon may be because this journal had reached out to more readers.

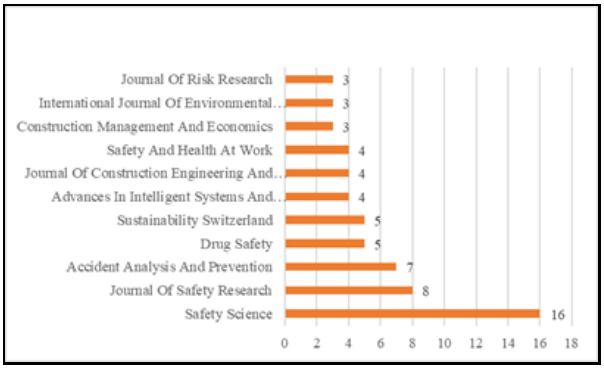

Fig-5: The most preferred publication outlets

Reference analysis is one of the primary bibliometric analysis documentations. The degree to which the publications have been cited in the following scientific literature is often used to measure their scientific impact and international

visibility. Table 2 summarised the top-five cited articles (based on the text's citation number) as per the Scopus database. D.A. Hofmann and F.P. Morgeson published an article with the highest number of citations (466 citations), equivalent to 21.18 citations per year. The article entitled "Safety-related behavior as a social exchange: The role of perceived organisational support and leader-member exchange". This article was published by The Journal of Applied Psychology in 1999. The number of citations can be described as actual data, which means that the article's citation will increase. This guide will serve as an excellent resource for novice researchers to explore workplace safety communication research by securitising relevant information from the article.

Table-2: The the top-five cited articles

Rank	Cites	Annual Citation	Authors	Title	Year	Source
1	466	21.18	D.A. Hofmann and F.P. Morgeson	Safety-related behavior as a social exchange: The role of perceived organisational support and leader-member exchange	1999	Journal of Applied Psychology
2	399	26.6	D. Jiang, V. Taliwal, A. Meier, W. Holfelder, and R. Herrtwich	Design of 5.9 GHz DSRC-based vehicular safety communication	2006	IEEE Wireless Communications
3	177	16.09	P. Kines, L.P.S. Andersen, S. Spangenberg, K.L. Mikkelsen, J. Dyreborg, and D. Zohar	Improving construction site safety through leader-based verbal safety communication	2010	Journal of Safety Research
4	129	12.9	P. Kines, J. Lappalainen, K.L. Mikkelsen, E. Olsen, A. Pousette, J. Tharaldsen, K. Tómasson, and M. Törner	Nordic Safety Climate Questionnaire (NOSACQ-50): A new tool for diagnosing occupational safety climate	2011	International Journal of Industrial Ergonomics
5	120	10.91	K.P. Cigularov, P.Y. Chen, and J. Rosecrance	The effects of error management climate and safety communication on safety: A multi-level study	2010	Accident Analysis and Prevention

Mapping Safety Communication Research with VOSviewer

This sub-topic provides a visual description to deepen the conclusions of the previous sub-topics. The VOSviewer software is used to evaluate co-citation and the authors' keywords co-occurrence. Fig. 6 displays the findings of co-citation analysis of publication outlets on safety communication research with a threshold of 20 citations and 43 sources. Safety Science is the most-cited journal with the best network links (red cluster) with a total link strength is 6338 and 354 citations. Safety Science was congregated in a similar cluster with the Accident Analysis and Prevention, Work and Stress, Journal of Loss Prevention, Professional Safety, Ergonomics, and Work Stress.

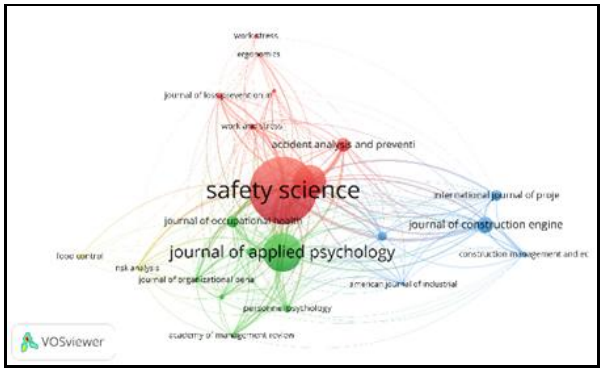

Fig-6: The co-citation analysis of publication outlets

VOSviewer also allows for the analysis of the most frequent keywords appearing in a given set of publications. In this analysis, VOSviewer had mapped the keywords of the authors. Fig. 7 provided a network diagram of the authors' keywords with

various colours, node sizes, font sizes, and the thickness of the connecting lines to illustrate the relationship with other keywords. The keyword "safety communication" in turquoise colour is the most frequent keyword. Different popular co-occurrence keywords in this review are "safety climate", "communication", "safety", and "safety behavior". This review confirms that research on safety communication at the workplace has an interdisciplinary perspective and connects with a wide range of fields, including communication, safety, safety behaviour, and safety climate. Although many new areas of study have emerged in the last decade, it may still be necessary for researchers to develop creative concepts, novel subjects, and methods or theories in this field of study. This can be accomplished by designing a safety communication model at the workplace with integrated components derived from the authors' keywords, as shown in Fig.7.

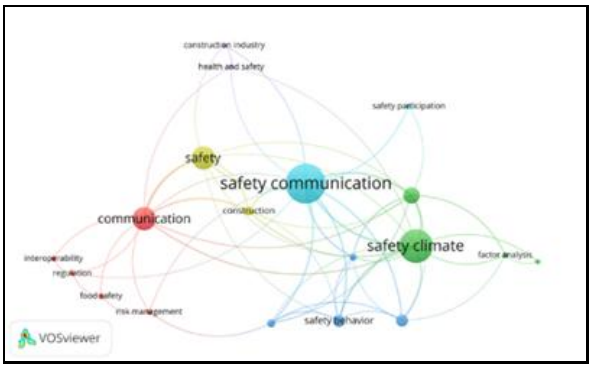

Fig-7: Network visualisation map of author keywords

Thematic Evolution Analysis of Safety Communication Research using SciMAT

The thematic evolution of safety communication research at the workplace is examined using the SciMAT software tool. The evolution map shows that; how thematic field evolution is linked over the study period. The nodes' size is reflected in the number of documents within a given theme, and links between nodes are proportional to the similarity in a topic. It will be at least one out of all the theme keywords that the theme will contain [33]. The themes share solid lines link identical labels, whereas the themes share similar keywords with different labels connected by a dotted connection [33].

The overlapping map allows the researcher to determine how stable the first and second period's data was. The horizontal line is the number of words that are shared. The forward-directed arrow shows how many keywords would be missing during the first period. The inward arrow indicates the number of new keywords, on the other hand. Key outputs of the SciMAT are graphical depictions of the thematic structure across the researcher's selected periods. A strategic diagram has grouped themes into four groups, as discussed in Table 1. The strategic diagrams in this review are presented in Fig. 8, Fig. 9, and Fig. 10. In these diagrams, the nodes' size is relative to the number of articles allied with each theme.

The first period (2006–2010), as shown in Fig. 7, has been inadequate, and only a few major themes have emerged. The themes are "occupational-accidents" in the motor themes, "managers" are in between motor themes and highly developed and isolated themes, while "safety communications" were in between motor themes and basic and transversal themes. In this study, "communication-technology" was found to be the highly developed and isolated theme, "standardisations" were in emerging and declining themes and "accidents" were in basic and transversal themes. Throughout this period, attention was focused on the "occupational-accidents". This is because, between 2006 and 2010, safety communication research has emerged and was compellingly necessary for safety performance and change implementation in overcome injuries and workplace accidents, as indicated in Fig.1.

Fig-8: Significant themes during the first period of study (2006-2010)

Three key motor themes identified during the second analysis period (2011-2015) are "questionnaires," "safety behavior" and "risk factors", as shown in Fig.9. "Questionnaires" is one of the most common thematic categories related to performance measures. This is because questionnaires are an essential research tool for assessing whether workers feel safe and comply with workplace rules. The information obtained

through questionnaires could be used to analyse critical factors related to risk prevention and safety behaviour at the workplace. It is also noted that most of the top five of the cited articles, as shown in Table 2, are quantitative studies that used questionnaires to learn about safety communication. This is because the human mind influences behaviour through psychology and the most unsafe behaviour is performed without proper thinking, making workers vulnerable to accidents at work [40]. Therefore, a questionnaire set through a quantitative study is needed to examine these factors and the relationship with safety communication.

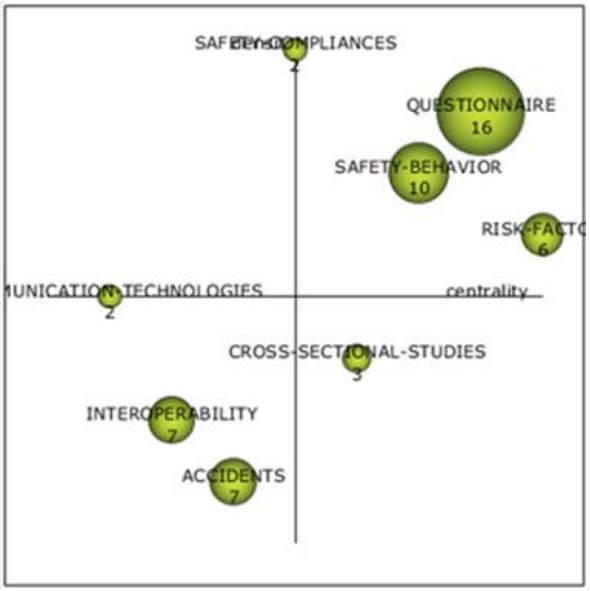

Fig-9: Significant themes during the first period of study (2011-2015)

In the third analysis period (2016-2020), there were three main themes, namely, "health-hazard", "food-and-drug-administration", and "organisational-culture". "Organisational-culture" was the most prominent motor theme in this period. From this study, organisational culture was the most critical subject in safety communication research from 2016 to 2020 and well established and essential for the organisation of a research field. Also, the finding of this study is in line with the results of the systematic review and metric analysis conducted by Lee et al. [41], which indicated that the critical factors of safety communication were (i) safety awareness, (ii) safety risks, (iii) health awareness, and (iv) health risks. These key factors are vital to assessing the effectiveness of safety and health publications and how they are used in different contexts.

Fig-10: Significant themes during the third period of study (2016-2020)

Fig. 11 shows the number of keywords has increased over time (based on the number of nodes). It represents a continuation of the emphasis on expanding safety communication research at the workplace. The number of emerging safety-communication themes is high, suggesting that safety communication research is continuously developing and growing. As a result of the complexity, dynamic, and uncertain nature of safety communication research, this is an expected trend.

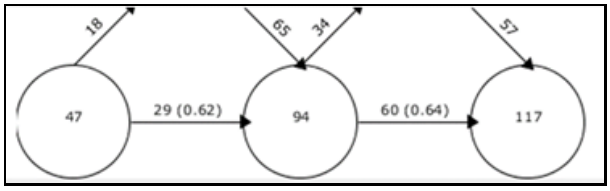

Fig-11: The keyword overlapping graph

The first-period evolution map (2006-2010) for safety communication research was based on "occupational-accidents", "safety-communications", "communication-technologies", "managers", "standardisation", and "accidents". These six themes underpin the argument that these issues have received relatively more attention in the literature. In the second period (2011-2015), the themes are closely related to the first period as follows: (i) "questionnaire" themes are closely associated with "occupational-accidents," (ii) "safety-behavior" is closely related to "occupational-accidents" and "safety-communication," (iii) "risk-factor" is related to "managers", and (iv) "accidents" emerge from "accidents" themes which are similar to "communication-technologies".

Based on the third period (2016-2020), the themes of "organisational-culture" are closely related to "questionnaire" in the second period and "occupational-accident" in the first period. "Prevention-and-control" themes were related to "safety-compliance" in the second period. This study found that "public-safety-communication" in the third period was associated with "communication-technologies" and "interoperability" in the second period. The "workgroup" themes emerged from "safety-compliance" themes in the second period. And, "interoperability" emerged from the same themes as in the second analysis period.

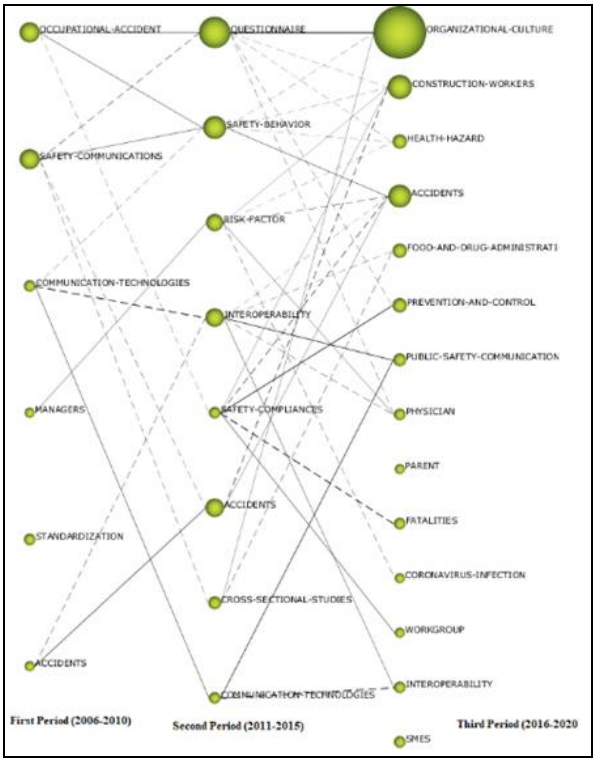

Fig-12: The map of thematic evolution

CONCLUSION

The bibliometric review promotes established directions for safety communication research, assesses emerging trends, and studies research evolution. It is possible to measure the state of the art with bibliometric analysis. Unfortunately, a host of drawbacks to the research question cannot be ignored. In this respect, other databases, such as Dimensions, Google Scholar, and Microsoft Academic, could have been used by future researchers to scrutinise publication trends and thematic evolution of safety communication research at the workplace. Based on a bibliometric review of 45 years of safety communication research (1975-2020), the findings could provide useful information for occupational safety and health researchers and professionals as follows:

- The number of publications on safety communication at the workplace had fluctuated over four decades, and the highest number of publications was 40 in 2020.
- Researchers from 11 countries have contributed to safety communication research with at least ten publications. The United States had the most publications with 99, followed by Australia (30 publications) and the United Kingdom (26 publications). This review shows that developed countries dominate the safety communication research field.
- RMIT University and Det Nationale Forsknings Center for Arbejdsmiljø had the highest number of publications with seven each. For 45 years; academics and professional experts have been engaged in safety communication research and have played an essential role in publishing this study field.
- The engineering field has become a key area due to new technologies, substances, and work processes. Therefore, understanding the latest technologies can be challenging, but it also provides an opportunity to raise awareness.
- The most influential sources were Safety Science. The Journal of Safety Research was the second most cited journal, and Accident Analysis and Prevention was the third most-cited journal. This phenomenon could be due to the increased readership of this journal.
- D.A. Hofmann and F.P. Morgeson published an article with the highest number of citations (466 citations), equivalent to 21.18 citations per year. The article entitled "Safety-related behavior as a social exchange: The role of perceived organisational support and leader-member exchange". The article was published by The Journal of Applied Psychology in 1999.
- The keyword "safety communication", "safety climate", "communication", "safety" and "safety behavior", "have more incredible co-occurrences, more strongly associated, and are related to other terms.
- This study identified that the first period's central themes (2006-2010) were "occupational-accidents". The "questionnaires", "safety-behavior", and "risk-factor" themes became the most significant number of publications and citations during the second period (2011-2015). "Organisational-culture" was the high number of publications in the motor themes during the third period of studies (2016-2020).

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