

# Publication Trends of Safety Knowledge Research: A Bibliometric Review

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Safety knowledge is characterised as a reasonable belief that enables individuals to manage and recognise risks effectively. This article aims to explain safety knowledge publications based on worldwide research trends. A bibliometric analysis of safety knowledge research from 1976–2019 was conducted via the Scopus database. The data was evaluated based on the global trend of publication, the contributions of countries, the contribution of journals, the distribution of institutions, the contributions of authors, and reference analysis. The results showed that safety knowledge research publications have risen significantly over the past 15 years, and found that the United States of America, China, and the United Kingdom were the most prominent publishing countries. Safety knowledge is an increasingly essential subject matter in managing occupational health and safety. This article is able to identify the relevant information and significant integrated fields of studies, adapting consistent findings for the practical application of safety knowledge in the workplace.

**Keywords:** *Bibliometrics, Publication trends, Scopus database, Safety knowledge, Occupational safety and health.*

## Introduction

The bibliometric analysis offers a macroscopic summary of vast volumes of scientific literature and is critical in making accurate decisions among scholars (de Oliveira et al., 2019; Gall, Nguyen, & Cutter, 2015). Nowadays, bibliometric analysis is widely used to evaluate articles, publishing countries, and institution performance (van Nunen et al., 2018). Also, the bibliometric analysis recognises parameters, such as the evolution trend of publications, research areas, and authors, which are attractive among scholars (Alauddin et al., 2018; de

Oliveira et al., 2019; Li & Zhao, 2015; Rusly et al., 2019). Furthermore, the bibliometric analysis was able to generate the scientific output of a particular research area (Li & Hale, 2016), and justify allocating research funds to funding agencies (Ugolini et al., 2015).

Bibliometrics is a handy research tool, as it is still impressive for researchers to provide a comprehensive review of relevant knowledge (Zhou, Goh, & Li, 2015) because scientific literature was conducted based on three primary forms (Cheng et al., 2011). First, generating, disseminating, and sharing academic information. Second, to rate academic and scholarly work to help disperse study funds. Third, to inform appointment and promotion decisions, and define the relative position of authors, agencies, and organisations. The various publications on a specific theme will indicate the range and scope of the research topics to allow bibliometrics to display the current trends, research directions, and field of study to review (Wang et al., 2014). Though reviewing processes do not include new models or methodologies, bibliometrics analysis still provides a significant contribution to the current development of research (Amin, Khan, & Amyotte, 2019).

In the field of occupational safety and health, bibliometric analysis has been conducted in a wide range of sub-domains, such as construction safety (Jin et al., 2019), road safety (Zou, Yue & Le Vu, 2018), and safety culture (van Nunen et al., 2018). Furthermore, a bibliometric analysis can be used to analyse subject maps and output distributions of core safety journals (Li & Hale, 2016), identify knowledge exchange between core safety science journals (Li & Hale, 2015), and link process safety, environmental protection, and industry 4.0 (Junior et al., 2018). Bibliometric analysis is, therefore, considered to be an acceptable method for assessing and applying research skills to gain insight into safety knowledge publications.

### **Safety Knowledge: A Brief Note**

In general, knowledge is described as a rational conviction that increases individual capacity to act effectively (Nonaka, 1994). In contrast, safety is designated as managing hazards at reasonable hazard levels (Mitropoulos, Abdelhamid, & Howell, 2005). Safety knowledge, therefore, can be defined as a reasonable belief that enhances a person's ability to manage recognised risks effectively to meet suitable risk levels (Dong et al., 2018). Hofmann, Jacobs, and Landy (1995) defined safety knowledge as an understanding of safety protocols and effective safety instruction. Safety knowledge, closely connected with workplace safety, is problematic to ratify and articulate, especially in tacit terms, but it can be implemented and used in task procedures and safety practices (Nonaka, Takeuchi, & Umemoto, 1996).

Safety research has focussed on how workers adhered to safety requirements and policies. However, the vital role of participation in workplace safety has also been recognised by previous researchers (Jiang & Probst, 2016). Participation in safety requires extra role practices that go beyond compliance and improve job safety (Christian et al., 2009). In this sense, employees should be proactively addressing safety issues, engaging in safety programs and

organisational safety training (Neal, Griffin & Hart, 2000), be involved in safety meetings (Neal & Griffin, 2006), and communicate safety issues to their supervisors (Mullen, 2005). A meta-analytical study conducted by Christian et al. (2009) indicated that safety knowledge had increased workplace safety participation among workers. This is because errors were found to be a significant factor in accidents at work, particularly among construction workers (Hasanzadeh, Esmaeili & Dodd, 2017). An unfortunate emphasis on hazard detection and inadequate response is a source of human error (Rozenfeld et al., 2010). Consequently, safety knowledge is essential to improve safety at construction sites to minimize human error (Olak et al., 2019).

Safety in the workplace has improved intensely over the last 100 years (Hofmann, Burke, & Zohar, 2017). However, based on the International Labor Organization (2020), about 2.3 million workers worldwide have died due to work-related injuries per year, corresponding to more than 6,000 deaths per day. Besides, the International Labor Organization (2020) also reported that approximately 340 million accidents occur at the workplace, and 160 million work-related injuries occur annually worldwide. Fu et al. (2020b) indicated that in 100 incidents, almost 98 per cent of incidents could be regulated and avoided by persons with appropriate actions. Fu et al. (2020a) regarded behavioural and human error as the leading cause of safety injuries and can be considered the critical inductors of construction safety injuries. Kuo et al. (2020) support this hypothesis, which highlights an influential safety culture capable of promoting safety behaviours, knowledge, and skills.

Safety is an essential component of successful business operations, growth, and sustainability. Nevertheless, organisations remain neglected by crucial safety measures, such as safety behaviour, attitude, and culture (Kuo et al., 2020). Safety culture includes behavioural, psychological, and situational elements (Cooper, 2000). The behavioural dimension focusses on employee habits, attitudes, and safety-related acts (Cooper, 2000). Several metrics are used to evaluate the organisational context of safety culture, including: participation, managerial contribution, employee satisfaction, compensation, and monitoring (Guldenmund, 2000). A safety culture aims to create a series of strategies that enable employees to pay attention to the hazards in their work environment, which can increase the quality of personal, and organisational safety (Morrow, Koves, & Barnes, 2014). Solid safety practices can affect the safety culture of an organisation (Vecchio-Sadus & Griffiths, 2004), and obedience to safety protocols (Choudhry, Fang, & Mohamed, 2007). In conclusion, the discussion shows that safety knowledge is fundamental in promoting a safety culture and improving safety behaviour. Therefore, this article aims to summarise and explain safety knowledge publications based on worldwide research trends.

## **Methods and Data**

This article presents a bibliometric analysis of safety knowledge publications from 1976–2019. A bibliometric analysis is an invaluable statistical method to map the new scientific knowledge

and to organise information, such as identifying research opportunities, and encouraging scientific research (de Oliveira et al., 2019). Thus, bibliometric analysis is a well-established method of evaluating and analysing scientific interest publications (Garousi, 2015). The data in this bibliometric analysis were retrieved using the Scopus database on 18 February 2020. If the same keywords were searched on different dates, the results of the search may be different due to the constant updating of articles in the database (Elsevier, 2017). The Scopus database was selected because the database had a broader index than the Pubmed, and Web of Science (Sweileh et al., 2017) databases. Moreover, several scholars have published papers in the Scopus database, and it has been frequently cited in previous studies (Khiste & Paithankar, 2017; Martín-Martín et al., 2018).

The bibliometric analysis in this study initiated with the selection of appropriate keywords. According to Sharma et al. (2018), the keywords chosen should be able to provide accurate information in line with the specific objectives of the analysis. The authors searched the command of ‘safety knowledge’ in the Scopus database, based on the TITLE-ABS-KEY (“Safety Knowledge”) in the article titles, abstracts, and keyword queries. The quotation marks were used to produce robust and precise search results. Upon completion of the search process, it approximately 1,257 documents in various publications were found. The authors also identified a total of 1,213 publications written in English, 14 in Chinese, and less than ten in other languages, such as French, Portuguese, and Korean.

The data and information, such as years, authors, the field of study, article sources, countries, and languages, were then exported in CSV, and RIS format to Microsoft Excel, Publish or Perish (PoP), and VOSviewer software for further analysis. The further analysis was based on several factors: global trend of publication, contributions of countries, contribution of journals, distribution of institutions, contributions of authors, reference analysis, and future research tendencies.

## **Results and Discussion**

### ***Global Trend of Publication***

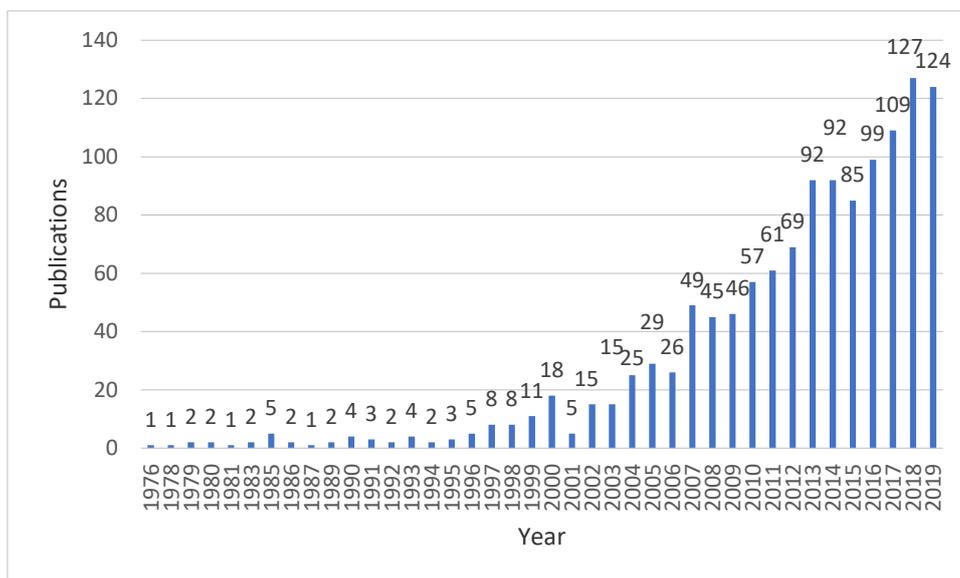
This section summarises the findings of the bibliometric analysis to define the trends, themes, and patterns of safety knowledge publications. The Figure 1 indicates the patterns of publication magnitude based on an annual basis. The oldest safety knowledge article traces back to 1976 and was published in the Journal of Occupational Accidents. The article was written by Sinnott (1976) and explored the value of safety teaching for engineering students to improve safety practices. Nevertheless, this report was unable to collect any quotes.

The number of safety knowledge research articles published between 1976–1995 was deficient, with less than five articles published annually. As shown in Figure 2, the visualisation of VOSviewer network reveals that Schwarz et al. (1993) received the highest citations, followed

by Guyer et al. (1989), and Kelly et al. (1987). The articles discussed the prevention of injury techniques. It has been shown that the most cited articles on injury issues were presented in 1976, and 1995. Safety knowledge seemed to attract researchers' interest after 2004, and the amount of scientific research production increased significantly. In addition to the growing number of articles, the context of safety knowledge research has been extended to include fire safety (Jaslow et al., 2004; Spinardi, 2019), food safety (Kramer & Scott, 2004; Odeyemi et al., 2019), and road safety (Elvik, 2004; Martensen et al., 2019). From 2017 to 2019, the research interest of safety knowledge grew further, with a steady rise in publications, in excess of 100.

Placed into context, the number of publications increased by an annual growth rate of 28.64 per cent between 2017, and 2019. This pattern demonstrates how the field has evolved, in which safety knowledge is still a contemporary and vital topic. Using a VOSviewer visualisation, the Figure 3 depicted articles by Baser et al. (2017), Moreb et al. (2017), Odeyemi et al. (2019), and Osaili et al. (2017), which dealt with food safety, and provided further references, among other publications. Thus, it has been shown that safety knowledge in food safety was widespread between 2017, and 2019.

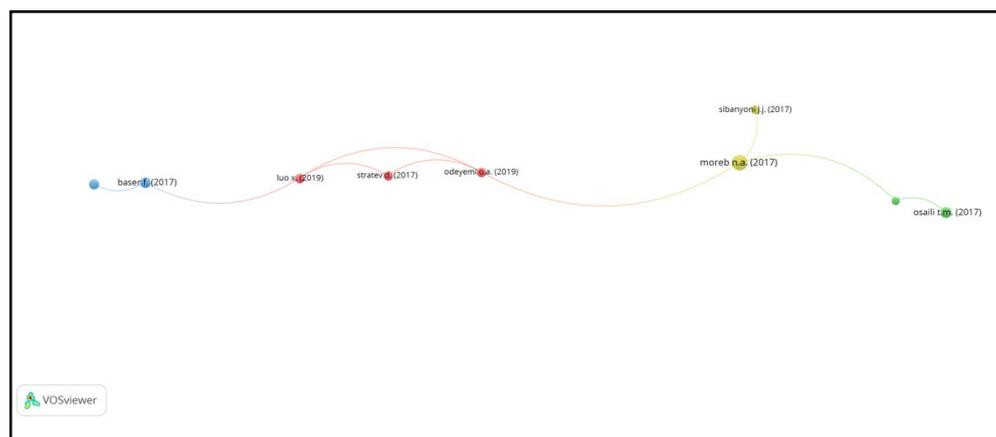
**Figure 1:** Global trend of publications



**Figure 2:** Network visualisation of citations by publications from 1976–1995



**Figure 3:** Network visualisation of citations by publications from 2017–2019



### *Contribution of Countries*

Scholars from 94 countries have contributed to disseminating safety knowledge with at least five publications. The Table 1 listed the top ten countries that contributed to the publications of safety knowledge. The ten most significant publications were in the United States of America (USA), with 465 publications (31.25 per cent); followed by China with 117 publications (7.8 per cent), the United Kingdom (UK) with 99 publications (6.65 per cent), Australia with 82 publications (5.51 per cent), Canada with 58 publications (3.90 per cent), Malaysia with 43 publications (2.70 per cent), Italy with 31 publications (2.08 per cent), Germany with 268 publications (3.8 per cent), Turkey with 26 publications (1.75 per cent), and South Korea with 24 publications (1.61 per cent). The results showed that developing countries dominated the publication of safety knowledge research over the span of 43 years.

The USA ranked the highest number with 717 citations, followed by China (783 citations), the UK (1778 citations), Australia (1699 citations), Canada (1239 citations), and China (783 citations). China was ranked third in the number of publications; the overall number of citations was lower than that of the United Kingdom, Australia, and Canada. China produced more research articles because, in 2016, the Chinese Government spent funding on research and development (R&D) at an increased rate of 10.60 per cent from the previous year to 1.57 trillion yuan (USD 235.9 billion). Approximately five per cent of the money spent on basic research was in line with the six per cent paid by the USA in 2012 (Jia, 2017). However, the UK had the highest overall citation in comparison with China. This is because two-thirds of the board members in the three primary funding bodies of the UK receive funding from the same entity they represented (Stavropoulou et al., 2019). It is fair, and to some degree beneficial, for a number of members of the board to be aware of the nature of the grant to be retained in the past, and to understand the scope and intent of the entity they serve.

**Table 1:** Contribution of Countries

Rank	Country	Number of Publications	Percentage (%)	Total Citation
1	United States	465	31.25	7238
2	China	117	7.86	783
3	United Kingdom	99	6.65	1778
4	Australia	82	5.51	1699
5	Canada	58	3.90	1236
6	Malaysia	43	2.89	291
7	Italy	31	2.08	711
8	Germany	26	1.75	315
9	Turkey	26	1.75	488
10	South Korea	24	1.61	229

### *Contribution of Journals*

As shown in Figure 4, the top ten academic journals from 725 active sources account for more than one-third of the total 1,257 publications on safety leadership research (251 publications or 34.60 per cent). Based on Figure 7, 'Food Control' was ranked first in the safety knowledge publications (77 publications or 10.62 per cent), followed by 'Safety Science' (33 publications or 4.55 per cent), the British Food Journal (24 publications or 3.31 per cent), Food Protection Trends (23 publications or 3.17 per cent), and Accident Analysis and Prevention (20 publications or 2.76 per cent).

**Figure 4:** Contribution of the top ten journals

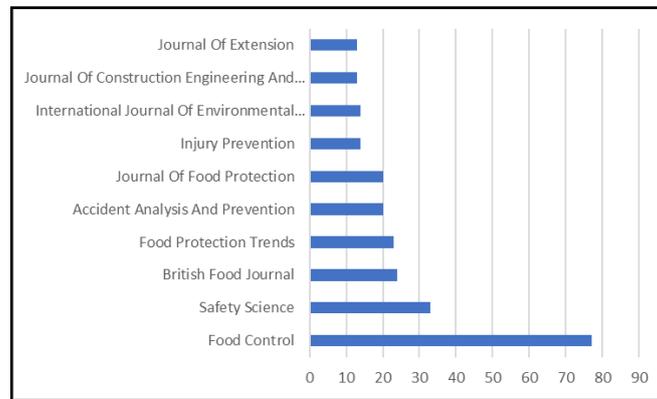
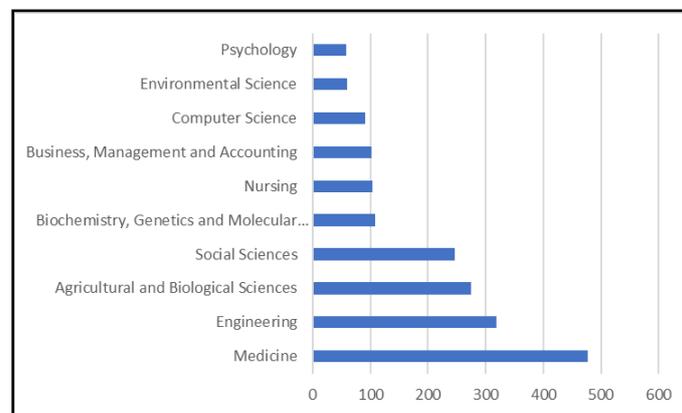


Figure 5 showed the top ten research hotspots that were the subject of the study. It showed that medicine ranked first in the field of safety knowledge, with 477 publications (22.04 per cent), followed by engineering (319 publications or 14.74 per cent). Over 43 years, both research hotspots have produced more than 300 publications of safety knowledge. Other significant contributors to the research of safety knowledge included: agricultural and biological sciences, social sciences, biochemistry, genetics, and molecular biology, nursing, business, management and accounting, computer science, environmental science, and psychology.

**Figure 5:** Research areas publishing on safety knowledge



### ***Distribution of Institutions***

The involvement of the institutions in safety knowledge has also been considered in this evaluation. i.e., based on at least five publications. The Table 2 reveals that the University of Guelph, and the University of Illinois in Chicago shared the highest number of safety knowledge publications. The Bloomberg School of Public Health was the second highest, followed by The Ohio State University, and the University of Toronto. According to the regional analysis, the University of Guelph in Canada was the leading institution for the distribution of safety knowledge, followed by the University of Illinois in Chicago, and the

Johns Hopkins Bloomberg School of Public Health in the USA. They are the top five powerful institutions monopolised by universities in the USA. Accordingly, these universities have the most powerful impact on profitability and engagement in the field of safety knowledge.

**Table 2:** Distribution of Institutions

Ranks	Institutions	Number of Publications	Percentage (%)
1	University of Guelph	17	2.01
2	The University of Illinois at Chicago	17	2.01
3	Johns Hopkins Bloomberg School of Public Health	15	1.78
4	The Ohio State University	14	1.66
5	University of Toronto	13	1.54

### *Contribution of Authors*

Since 1976, a total of 1,257 safety knowledge research studies have been written by 4,720 authors. The Table 3 records the author's information that has been produced in more than five publications. Dworkin, M. S. was the most successful author in writing a total of 12 publications. Based on Table 3, Dworkin, M. S., and Jevšnik, M. are among the most active authors in this field of research, publishing more than ten publications on safety knowledge.

**Table 3:** Contribution of Authors

Ranks	Authors	Number of Publications	Percentage (%)
1	Dworkin, M. S.	12	2.09
2	Jevšnik, M.	10	1.74
3	Raspor, P.	9	1.57
4	Schwebel, D. C.	9	1.57
5	Byrd-Bredbenner, C.	8	1.39
6	Gielen, A. C.	7	1.22
7	Park, C. S.	7	1.22
8	Probst, T. M.	7	1.22
9	Sanlier, N.	7	1.22
10	Shields, W. C.	7	1.22

### *Reference Analysis*

Reference analysis is one of the main bibliometric indexes. The Table 4 summarises the citation metrics for the document retrieved on 18 February 2020. As noted, there were 1,257

publications in 43 years (1976–2019) of safety knowledge. The citation metric was obtained by Publish or Perish (PoP) software by importing files in an RIS format from the Scopus database.

**Table 4:** Citation Metrics

Metrics	Data
Publication years	1976–2019
Citation years	43 (1976–2019)
Papers	1,257
Citations	17,523
Cites/ year	398.25
Cites/ paper	13.94
Authors/ paper	3.67
h-index	60
g-index	97
hI, norm	34
hI, annual	0.77

The Table 5 lists the top ten most cited publications (based on the number of citations), as per the Scopus database. The article written by A. Neal, M. A. Griffin, and P. M. Hart, and entitled “The impact of organizational climate on safety climate and individual behavior”, and which was issued by ‘Safety Science’, attained the highest number of citations of a total of 701 quotes, equivalent to 35.05 citations per year. The second rank goes to the article written by M. S. Christian, J. C. Bradley, J. C. Wallace, M. J. Burke, entitled “Workplace Safety: A Meta-Analysis of the Roles of Individuals and Situation Factors”, with a total of 631 citations and cites approximately 57.36 per year.

**Table 5:** Top ten cited articles

Ranks	Cites	Authors	Title	Year	Source	Cites Per Year	Cites Per Author
1	701	A. Neal, M. A. Griffin, P. M. Hart	The impact of organizational climate on safety climate and individual behavior	2000	Safety Science	35.05	234
2	631	M. S. Christian, J. C. Bradley, J. C. Wallace, M. J. Burke	Workplace Safety: A Meta-Analysis of the Roles of Person	2009	Journal of Applied Psychology	57.36	158

		C. Wallace, M. J. Burke	and Situation Factors				
3	457	A. Zacharatos, J. Barling, R. D. Iverson	High- performance work systems and occupational safety	2005	Journal of Applied Psychology	30.47	152
4	302	S. Gherardi, D. Nicolini	To Transfer is to Transform: The Circulation of Safety Knowledge	2000	Organization	15.1	151
5	267	M. J. Burke, S. A. Sarpy, K. Smith- Crowe, S. Chan-Serafin, R. O. Salvador, G. Islam	Relative effectiveness of worker safety and health training methods	2006	American Journal of Public Health	19.07	45
6	266		Microbiological safety evaluations and recommendations on sprouted seeds	1999	International Journal of Food Microbiology	12.67	0
7	174	J. Kennedy, V. Jackson, I. S. Blair, D. A. McDowell, C. Cowan, D. J. Bolton	Food safety knowledge of consumers and the microbiological and temperature status of their refrigerators	2005	Journal of Food Protection	11.6	29
8	168	P. Mitropoulos, T. S. Abdelhamid, G.A. Howell	A systems model of construction accident causation	2005	Journal of Construction Engineering and Management	11.2	56

9	164	D. Fang, Y. Chen, L. Wong	Safety climate in the construction industry: A case study in Hong Kong	2006	Journal of Construction Engineering and Management	11.71	55
10	147	M. BaÅŸ, A. Åžafak Ersun, G. KivanÅŸ	The evaluation of food hygiene knowledge, attitudes, and practices of food handlers' in food businesses in Turkey	2006	Food Control	10.5	49

### Discussion and Conclusions

From this bibliometric analysis, it can be inferred that safety knowledge is an increasingly important subject, and a large number of these publications have been shown to be concerned with applying safety knowledge in managing occupational health and safety. This can be seen as a significant step forward in resolving the lack of up-to-date bibliometric analysis that applies specifically to safety knowledge for guidance on how current literature is organised, and offers research directions that have not yet been adequately covered by the documentation.

This analysis examined the evolution of safety knowledge publications and identified a significant increase over the past 15 years. Comparing the most influential countries has shown that the USA, China, and the UK are of considerable importance. Since all these countries have spent more budget on increasing safety knowledge research, data from each of the contributing institutions indicates that the University of Guelph, and the University of Illinois in Chicago share the highest number of safety knowledge publications. The most prominent authors are Dworkin, M. S. from the University of Chicago, USA, who has written 12 safety knowledge publications. The publications Food Control, Safety Science, and the British Food Journal are the most cited journals. The post drew up by A. Neal, M. A. Griffin, and P. M. Hart, entitled "The Impact of Organizational Climate on Safety Climate and Individual Behavior", and published by Safety Science, earned the most significant number of citations, with a total of 701, equal to 35.05 citations each year. The importance of the practical aspects of safety knowledge publications has been demonstrated by the review of the most cited publications.

Through bibliometrically structuring data on safety knowledge research publications, the core scientific contribution of this article lies in systematising safety knowledge literature, identifying highly relevant publications, authors, journals, institutions, and countries in this field, as well as identifying and summing up scientific gaps identified in the recent paper. This



bibliometric review promotes the examination and integration of established directions in this research area, and new directions emerging.

This article helps the management of organisations that choose to use safety knowledge to manage safety-related operations in accordance with the most relevant literature. Since the use of safety knowledge is still a relatively new technique, they will face difficulties and challenges before, and during implementation. The article defines and integrates significant field studies and study groups, allowing the relevant results to be applied to the practical application of safety knowledge in safety-related operations to improve safety and health management in all organisations.

One limitation of this article is the inability to determine the most widely used keywords, as the database data was insufficient, resulting in marginal tests. Besides, the essence of bibliometric analysis per se is minimal. Only articles that meet the search parameters and refinement requirements, as stated in the methodology section (“safety knowledge”), were included. It is a limitation of this research, which restricts empirical results and does not allow different organisations to understand safety knowledge fully. Another disadvantage is confining the results to the Scopus database. For a consistent result, further research should be undertaken to evaluate the pattern of safety knowledge publications in specific organisations, such as manufacturing, construction or health settings.

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