

Uncovering Research Trends in Safety Culture in the Global Construction Industry: A Bibliometric Analysis (1995-2020)

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ABSTRACT

Introduction: Safety culture has mainly been used across safety management literature to describe the level of safety within workplaces. This paper presents the research landscape and scientific developments on safety culture in the global construction industry.

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was employed to identify, screen, and analyze the published documents indexed in the Elsevier Scopus database. Next, the research landscape and scientific developments on the topic were examined by bibliometric analysis (BA) through co-authorship, keywords co-occurrence, and citations.

Results: Results showed that 738 documents were published and indexed on the topic between 1995 and 2020. The findings showed that articles are the preferred medium, whereas *Engineering* is the preferred subject theme for published documents on the topic. The journal of *Safety Science* (published by Elsevier) is the most influential source of publications on the topic. In contrast, Dongping Fang, based at *Tsinghua University* (China), is the most influential researcher due to the substantial research grants and financial support from the National Natural Science Foundation. Further analysis showed that the most prolific authors on the topic are based in China, Australia, and Indonesia, although the United States has published the most documents. BA also revealed large networks of researchers and co-occurring keywords and the organisations and countries that currently exist, collaborate, and cite each other works on the topic.

Conclusion: The findings indicate that safety culture in the global construction industry has undergone significant scientific developments resulting in high research impact mainly due to its role in preserving the health and safety of workers.

Key words: Construction Industry, Bibliometrics, Safety Culture, Safety Performance.

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INTRODUCTION

The construction industry is the fundamental driving force for socio-economic growth and infrastructural development in many societies of the world. The industry provides structures and critical infrastructure for housing, schools, hospitals, and offices, among others. Furthermore, the construction industry provides direct and indirect jobs and other means of livelihood for the millions of people who build, operate, monitor, or maintain such structures worldwide.^{1,2} However,



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the industry is considered one of the most hazardous workplaces due to its propensity for accidents, injuries, and fatalities.¹ Based on data from the Occupational Safety and Health Administration (OSHA), the most popular types of accidents that frequently occur during construction are electrical exposure, caught in between, falls from height, and being struck by moving or falling objects.³⁻⁵ Consequently, these construction accidents are typically termed the “fatal four” and account for the highest cases of accidents, injuries and deaths in the industry.^{6,7}

Given this scenario, numerous researchers have sought to identify and address the root causes of accidents in the construction industry. Among the most common solutions proposed by researchers is establishing occupational health and safety training programmes for workers.⁸⁻¹⁰ Other schemes have been developed to identify, determine, and examine the hazards and causes of construction site accidents and develop appropriate measures and corrective actions. One of the most cited solutions is the design, development and implementation of a robust safety culture or climate at construction sites or workplaces worldwide.¹¹⁻¹³

Safety culture is a critical concept of safety studies that is typically used to identify, understand, and address the occupational hazards and root causes of accidents, injuries, and fatalities in worksites.¹⁴ Wamuziri opined that safety culture is an integral part of organizational culture and workplace ethics, particularly in the construction industry. Workers’ well-being depends on the employer’s commitment to their general welfare.¹⁵ Furthermore, the authors opined that cultural changes have resulted in the establishment of health laws and safety guidelines in the construction industry.¹⁵ The cultural shifts have been galvanized by factors such as the top management commitment, planning, information sharing, risk assessment and control, and the involvement, training, and coordination of the employees.¹⁵

Over the years, numerous studies had attempted to examine the concept of safety culture and determine its correlation to organizational culture as it relates to human health and occupational safety in the construction industry. Misnan and Mohammed proposed a conceptual framework for safety culture in the construction industry in Malaysia.¹⁶ The study revealed that safety culture is dependent on the safety practices performed by workers and an effective safety

management system (SMS). The conclusion was that the presence of an SMS could lower the occurrence of accidents, injuries and fatalities experienced by workers in the construction industry. Similarly, Choudary developed a model for safety culture in the construction industry.¹⁷ The study reported that safety culture involves perception, psychology, behavior, and managerial factors.

The review of literature on the safety culture and the construction industry in the Elsevier Scopus database reveal numerous published documents ranging from articles, reviews, and conference papers, among others. The published articles provide critical insights into the theories, concepts, tools/methods, prospects, and challenges of developing and implementing safety culture in the construction industry. On the other hand, the published reviews, conference papers, and books provide an overview or summary of the findings on the topic. Due to the vast literature, theoretical concepts, and empirical findings on the topic, there is an urgent need to critically evaluate the research landscape and scientific growth of the topic, which is currently lacking in the literature.

Therefore, this paper seeks to present and highlight the research progress and scientific developments on the safety culture and construction industry. The methodology included PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) technique to identify systematically, screen, and review the literature. Whereas the bibliometric analysis was performed to examine the research landscape and scientific developments between 1995 and 2020 as indexed in the Scopus database. It was envisaged that the findings would provide synergy between the plethora of published literature on the topic and a critical understanding of the field’s current status and future developments.

METHODS

In this paper, the research trends on safety culture in the global construction industry were examined through bibliometric analysis from 1995 to 2020. This period was selected because it allows for the collation of a large amount of data which is reliable and accurate for data analysis using VOSViewer software. Consequently, the PRISMA (preferred reporting items for systematic reviews and meta-analyses)^{18,19} technique was chosen for the identification, selection, and analysis of the related documents from the Scopus

(Elsevier) database, based on Figure 1. The related documents on safety culture in the global construction industry were identified and selected using an aptly designed search query based on the keywords. On 13th November 2021, the search query (“Safety culture” OR “Safety climate” AND “Construction”) was designed and executed in the Scopus database to retrieve the related documents. The search identified and returned 744 documents comprising articles, conference papers, reviews, book chapters, books, short surveys, along with retracted, erratum and notes.

Next, the documents were screened to remove the non-conventional peer-reviewed documents (such as short survey, retracted, erratum and notes), resulting in 738 documents. The CSV (comma-separated variables) data for the final set of documents was recovered and analyzed to examine the publication trends, top researchers, organizations, and countries carrying out research activities on safety culture in the global construction industry. The CSV was imported into VOSViewer software (version 16.6) to examine the research landscape on the topic through the co-author, co-occurrence, and citation analysis. Lastly, the network visualization maps of the author, affiliations, organizations, and countries related to the topic were generated and examined in detail.

RESULTS

Publication trends

The publication trends on the safety culture in the global construction industry were examined based on the recovered documents from the Scopus database published between 1995 and 2020. Figure 2 presents the publication trend in the subject area over the 25-years

As observed, the number of publications on the topic has increased progressively from 1 to 83 documents between 1995 and 2020. However, the publication trend shows that interest in the area was prolonged, as evident in a low number of publications (i.e., below 10 annually) between 1995 and 2003. Over the years, the number of publications on the topic increased due to the growing concerns about accidents, injuries, and deaths on construction sites globally. Given this, many safety experts have strongly advocated for improved health and safety practices on construction sites, which have resulted in improved accident reporting, employee personal protection, faults detection as well as training, safety research and workplace

management. Therefore, numerous researchers have taken up health, safety, and environment as their core research interests in the academic, industry and policy sectors. Consequently, there has been a growing body of published documents on safety culture in the global construction industry, which has resulted in numerous publications in various mediums. Figure 3 shows the distribution of published documents on the topic based on the PRISMA screening process.

As observed, the screened and identified publications on the topic returned 738 documents comprising articles, conference papers, reviews, conference reviews, book chapters, and books. The most preferred type of documents among researchers in research articles with 422 documents, and subsequently conference papers (255), and reviews (23).

The effect of such choices on the researchers working in the area of safety culture in the global construction industry was examined in this study. Figure 4 presents the distribution of publication sources or scholarly journals selected by researchers on the topic. As observed, the top journals that publish research on safety culture in the global construction industry are Safety Science with 52 documents, Journal of Construction Engineering and Management (40), Journal of Safety Research (21), Construction Management and Economics (15), and Engineering Construction and Architectural Management (15). Other notable journals include; Advances in Intelligent Systems and Computing, International Journal of Environmental Research and Public Health, American Journal of Industrial Medicine, Accident Analysis and Prevention, Iran Occupational Health, and the Journal of Management in Engineering.

The outlined journals that publish documents on the topic are hosted by various prestigious publishers such as Elsevier, Taylor & Francis, Emerald and ASCE (American Society of Civil Engineers). Furthermore, the journals are indexed or categorized based on various subject themes in the literature. Figure 5 presents the various subject themes for research on safety culture in the global construction industry.

As can be observed, Engineering is the subject theme with the most significant number of documents (494), whereas Medicine, Business, Management and Accounting, Social Sciences, and Computer Science had 172, 148, 128, 172, and 61 documents, respectively. Furthermore, an analysis of the network

of collaborations among authors, organizations and countries is presented in section 3.3.

Top authors, organizations, and country trends

The analyses of the top authors, organizations, funding agencies and countries working on any topic of research are an integral part of bibliometric studies.²⁴⁻²⁷ It also presents an overview of the critical stakeholders and most prolific researchers making a scientific impact on any research topic.²⁸⁻³⁰ Figure 6 presents the top 10 researchers working on safety culture in the global construction industry.

As observed, the most published researchers in the topic as deduced from the Scopus database during the study period is Dongping Fang, who is based at the prestigious Tsinghua University (China) with 23 published documents. This is closely followed by Albert Chan (Hong Kong Polytechnic University, Hong Kong) and Helen Lingard (RMIT University, Australia), both with 16 publications each. The trio of Yingbin Feng (Western Sydney University, Australia), Yusuf Latief (Universitas Indonesia, Indonesia), and Rossy Machfudiyanto (Universitas Indonesia, Indonesia) have published 13 documents each. Further analysis was performed to examine the affiliations and countries that have published the most research works on the topic. Figure 7 shows the affiliations of the top researchers and studies on the topic in the literature.

The findings indicate that the top affiliations for researchers on safety culture in the global construction industry are primarily based in Australia, China, Hong Kong, and Indonesia. This confirms the earlier submission that the work of researchers based on the continents of Asia and Oceania are significant stakeholders on the topic. However, the country basis analysis of the published documents on the topic, as illustrated in Figure 8, shows that the United States has the most published documents, followed by China, Australia, the UK, and Hong Kong.

Figure 9 shows the top 10 funders of research on safety culture in the global construction industry worldwide. As observed, the top funders of research on the topic are primarily comprised of national institutes, departments, ministries, and universities. The top funder of research on the topic is the National Natural Science Foundation (China), with 32 funded/published documents. This is followed by the National Institute for Occupational

Safety and Health (United States), Department of Health and Human Services (United States), and the Centre for Disease Control and Prevention (United States), and the Ministry of Education (China), with 22, 19, and 18 funded/published documents, respectively. As observed, the most significant funders (i.e., top 5) of the research topic are based in the United States (3) and China (2) with 19.6 publications on average.

Other top organizations that provide funding for research on the topic are the Hong Kong Polytechnic University (China), Australian Research Council (Australia), and the European Commission (Europe). In general, the findings indicate that research funding and other forms of financial support for the topic are widely available worldwide, which in turn reflects its dynamic impact on human health, safety, and the environment. However, the scientific impact of safety culture on the construction industry worldwide can be further examined through bibliometric analysis. Hence, section 3.3 presents the bibliometric analysis of the scientific landscape along with the research impact of the authors, organizations, affiliations, and countries actively working on the topic.

Bibliometric analysis

Bibliometric analysis is a mathematical and statistical tool widely used for identifying, organizing, and analyzing the research landscape and scientific trends on any given topic of scientific interest.³² It is also an essential technique for assessing the growth and development of any research area to understand the current trends and future directions.³³ Over the years, the tool has been used to examine various topics and disciplines ranging from energy^{34, 35}, climate change^{36, 37}, waste management^{38, 39}. In this study, the bibliometric analysis was carried out to identify and examine the scientific literature on safety culture in the global construction industry. The BA focuses on co-authorship, co-occurrence, and citation analyses of the scientific literature on the safety culture and the construction industry using VOSViewer software.

Co-authorship analysis

The co-authorship analysis of the researchers working on safety culture in the global construction industry was carried out using VOSViewer. Hence, a network visualization feature of the software was used to generate the map for the topic based on the following criteria of 200 maximum authors per published

manuscript. The minimum number of publications per author was 3, which generated 1525 documents based on the analysis criteria. Consequently, the network visualization map was generated for the resulting 69 connected items generated from 135 items that fulfilled the screening criteria. Figure 10 shows the network visualization of co-authorship on the safety culture in the construction industry examined in this study.

The network visualization map shows numerous networks of authors, amounting to 11 clusters that are actively collaborating on the topic. Furthermore, it can be observed that the blue cluster is the most connected to others, based on the size of the nodes and link strengths in Figure 10. The high network of collaborations is mainly due to the work of Dongping Fang (Tsinghua University, China). Hence, the extent of such national or international collaborations is examined in the country-based co-authorship analysis in the next section.

Country-based co-authorship analysis

Collaboration is an essential aspect of research culture, which according to the findings of Baker ⁴⁰, presents a multidimensional perspective to scientific research and technological development. Figure 11 shows the network visualization of country-based co-authorship analysis on safety culture in the global construction industry.

Co-occurrence analysis

The co-occurrence analysis provides critical insights into the frequency in which related and selected keywords on any given research topic are cited in the scientific literature. In this paper, the co-occurrence of author and index keywords on safety culture in the global construction industry was examined. Figure 12 shows the network visualisation map on the co-occurrence of author keywords on safety culture in the global construction industry.

The network visualisation of the most occurrent index keywords on safety culture in the global construction industry is presented in Figure 13.

Figure 13 shows that the most occurrent index keywords are construction industry, organisational culture, organisational safety, health and safety, workplace, organisation and management, communication, and young adult, among others.

Citations Analysis

The frequency of citations observed for published documents on the subject is critical to its research impact. In this study, the analysis of the most cited authors, journals, and countries on safety culture in the global construction industry was examined as depicted in Figures 14-16.

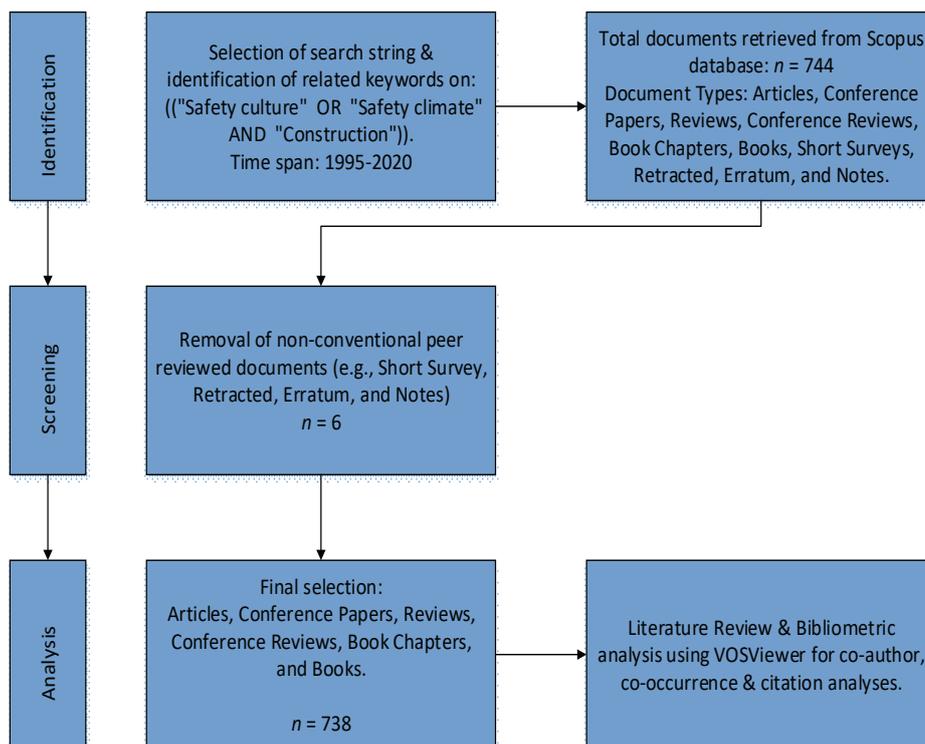


Figure 1: PRISMA Technique for identifying, screening, and analysis.

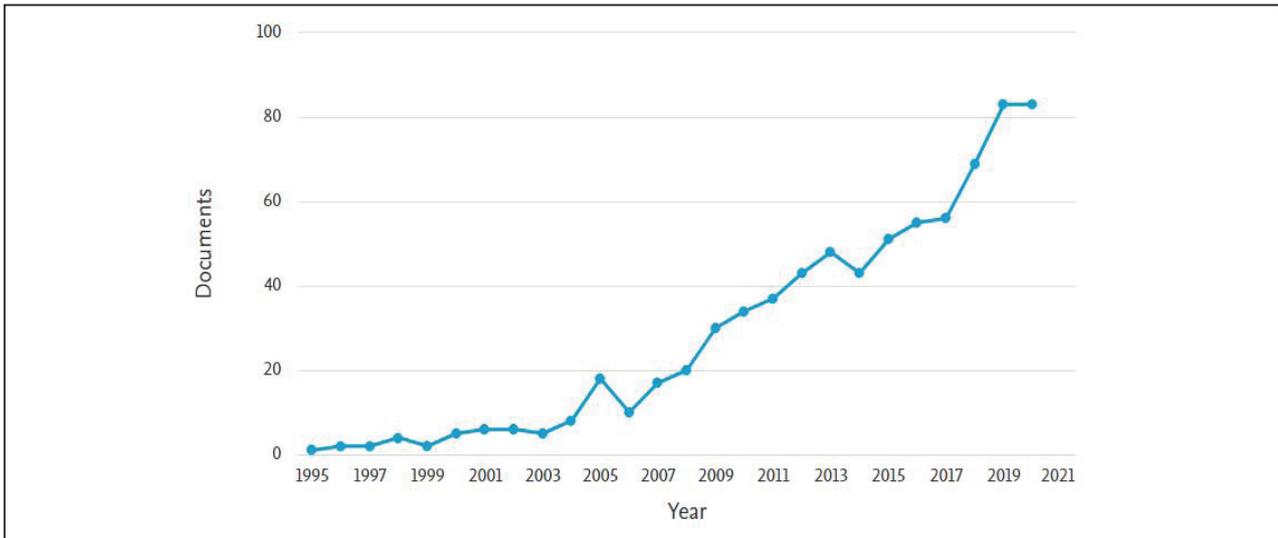


Figure 2: Publication trends on safety culture in the global construction industry

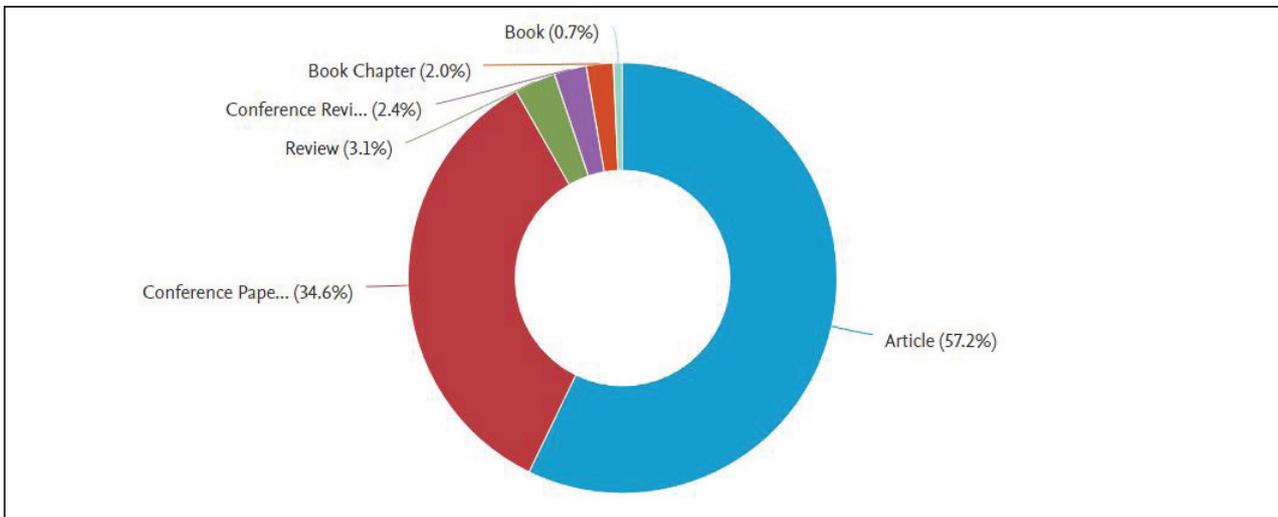


Figure 3: Distribution of published documents on safety culture in the global construction industry



Figure 4: Publication sources for safety culture in the global construction industry

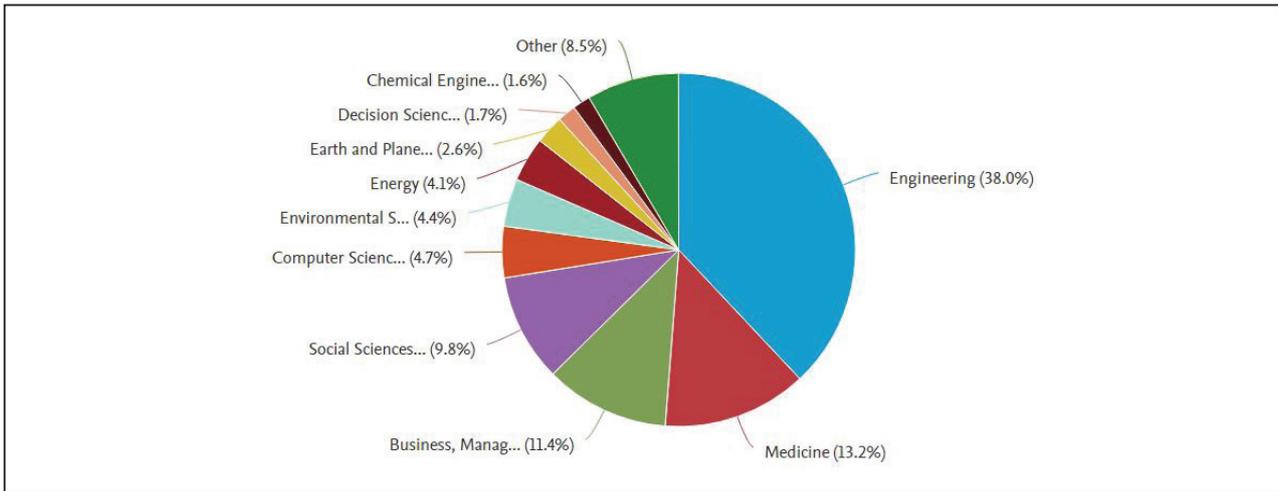


Figure 5: Subject themes for research on safety culture in the global construction industry

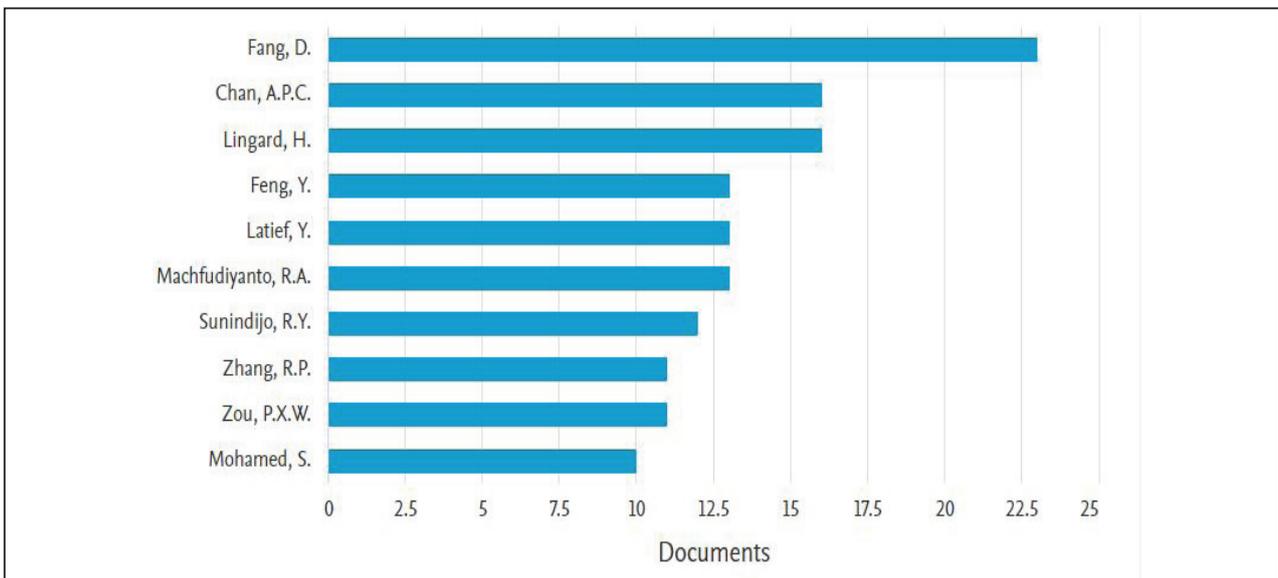


Figure 6: Top authors working on safety culture in the global construction industry

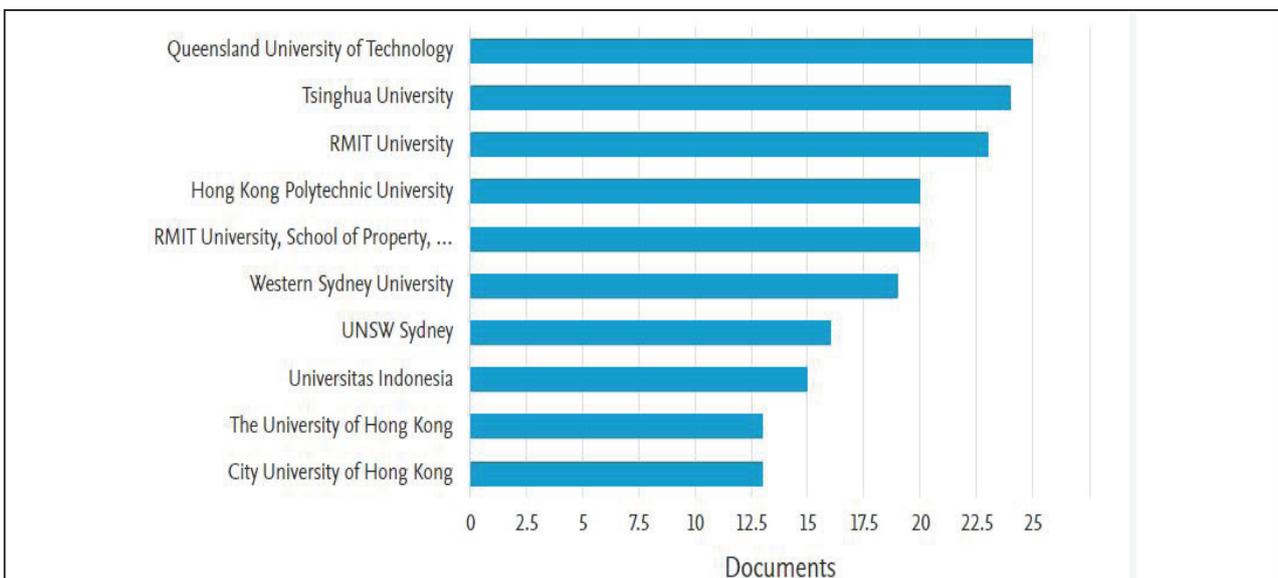


Figure 7: Top affiliations for research on safety culture in the global construction industry

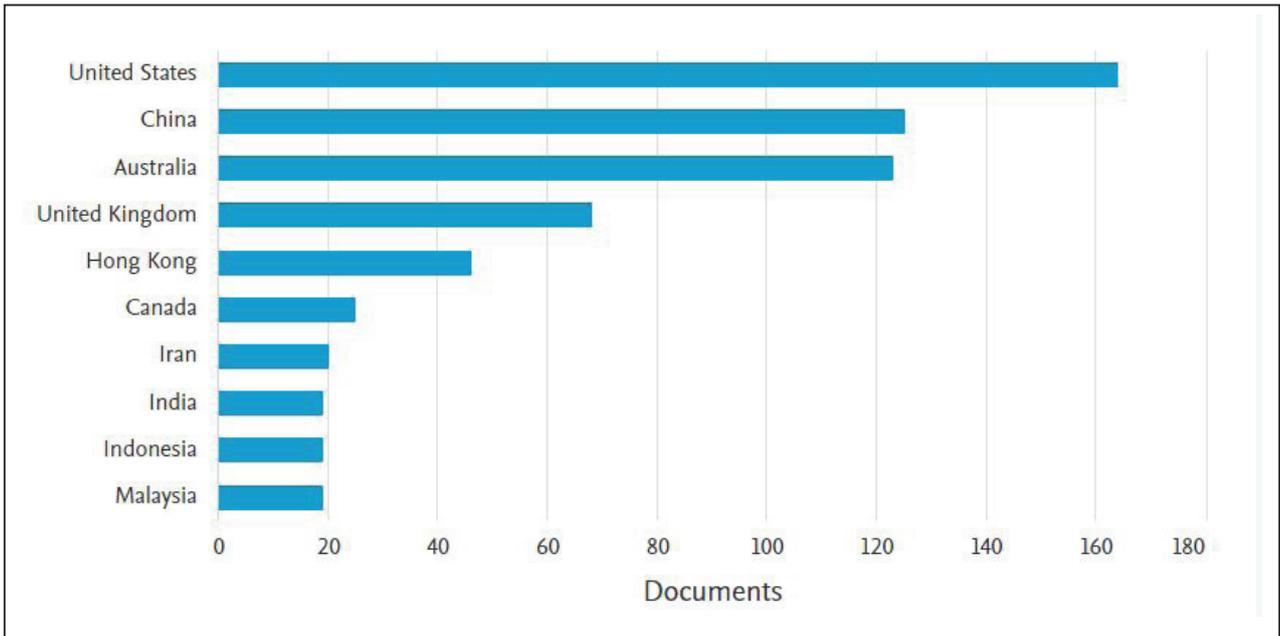


Figure 8: Top countries researching safety culture in the global construction industry

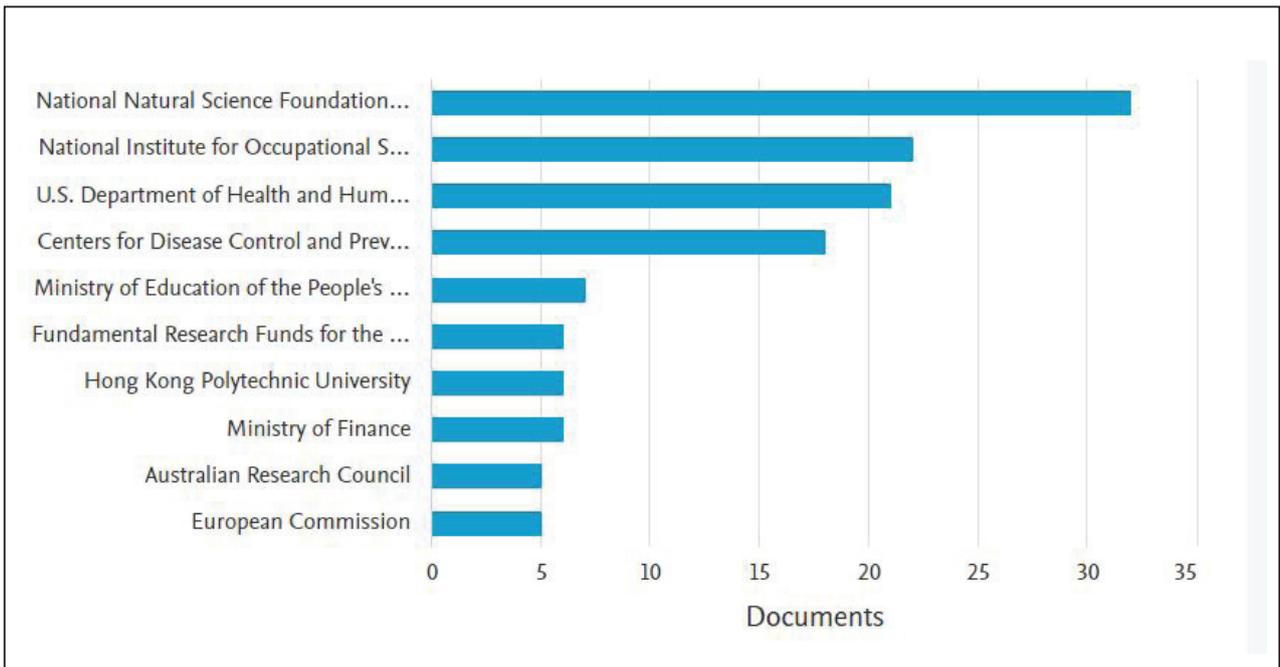


Figure 9: Top research funders for safety culture in the global construction industry

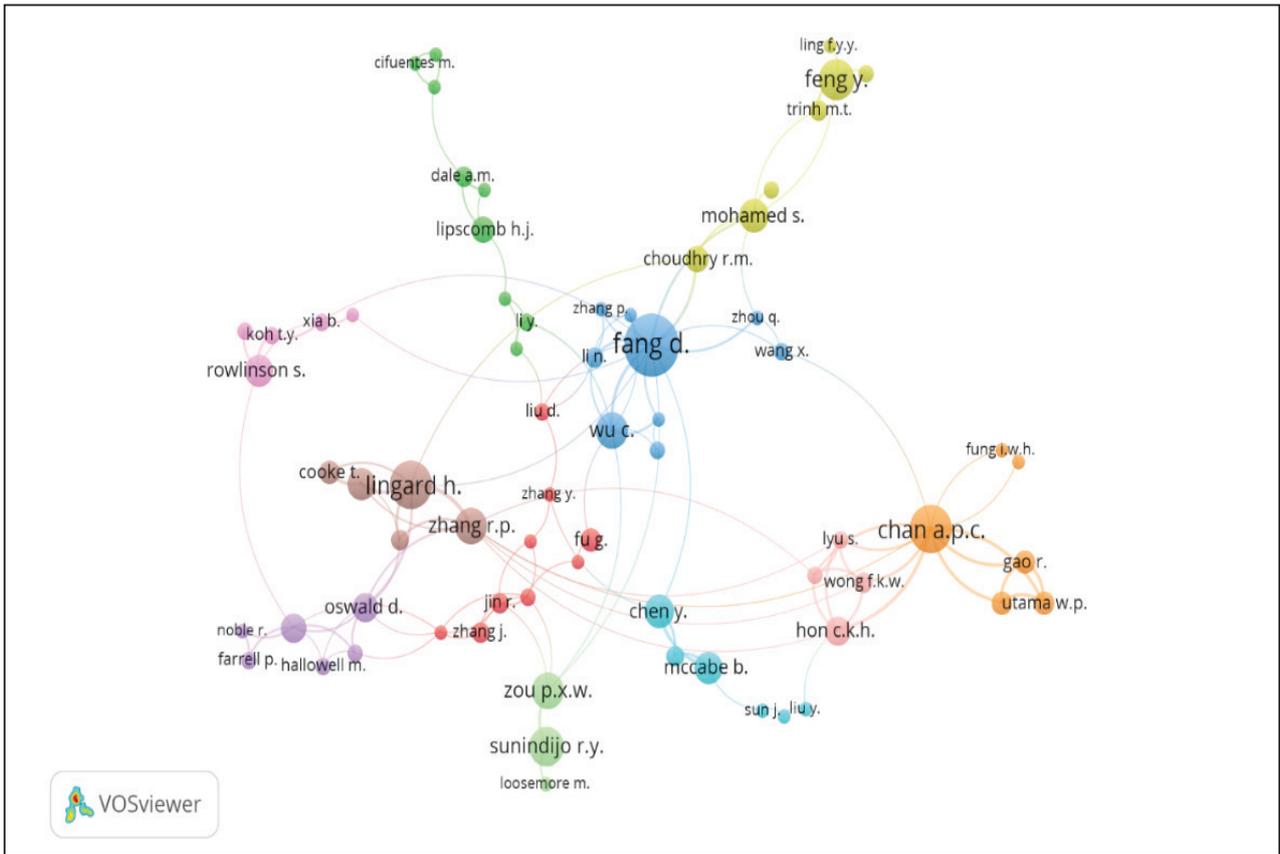


Figure 10: Network visualization of co-authorship on the safety culture in the construction industry

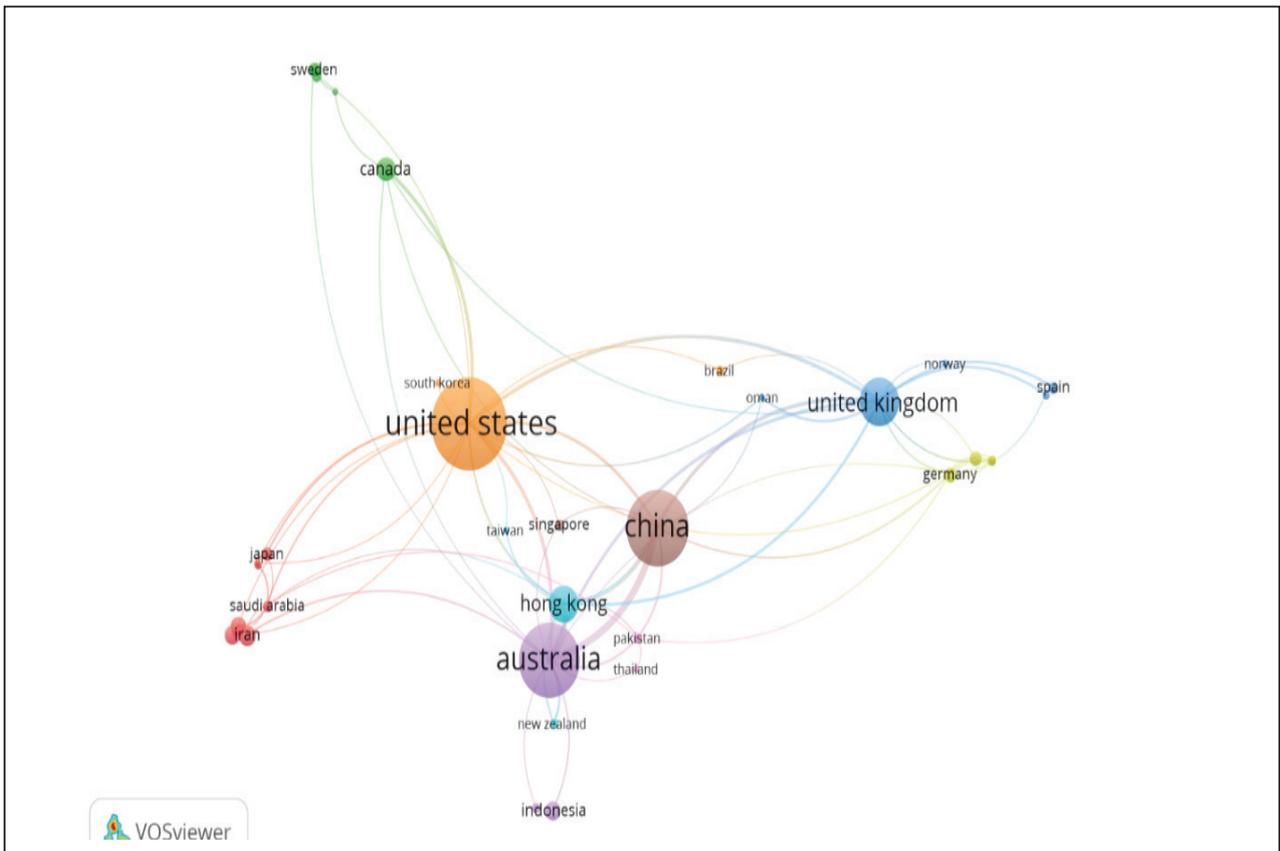


Figure 11: Network visualization of country-based co-authorship analysis on safety culture in the global construction industry

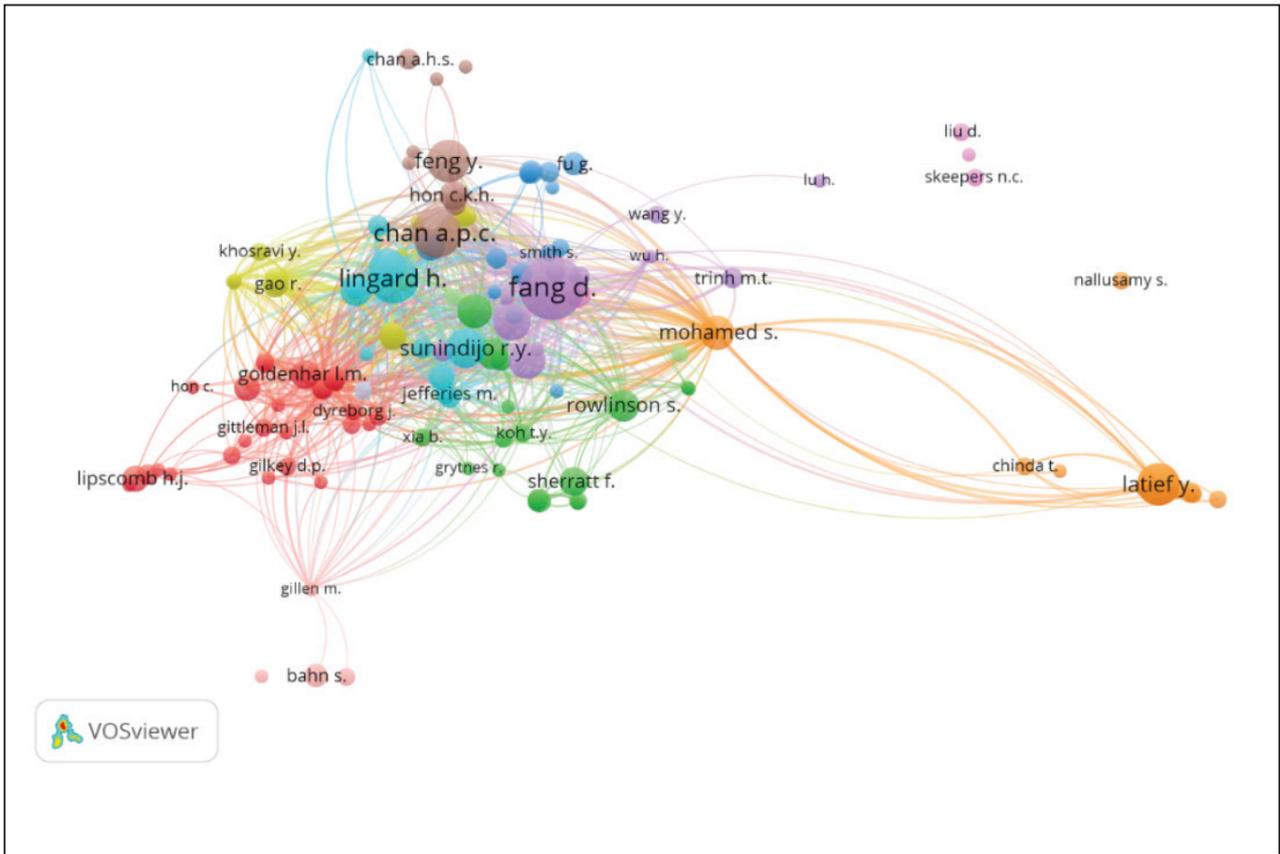


Figure 14: Network visualization of the citation analysis for authors

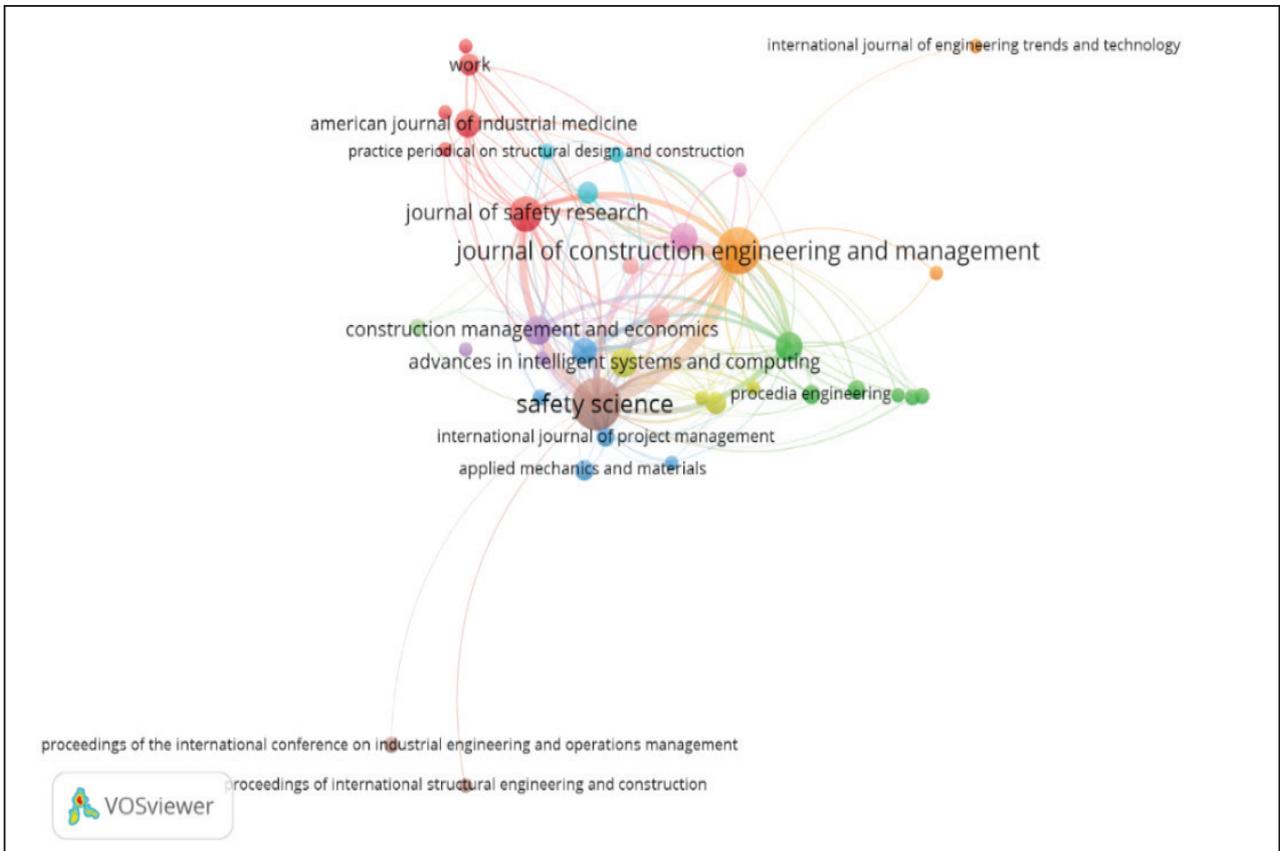


Figure 15: Network visualization of the citation analysis for journals/sources

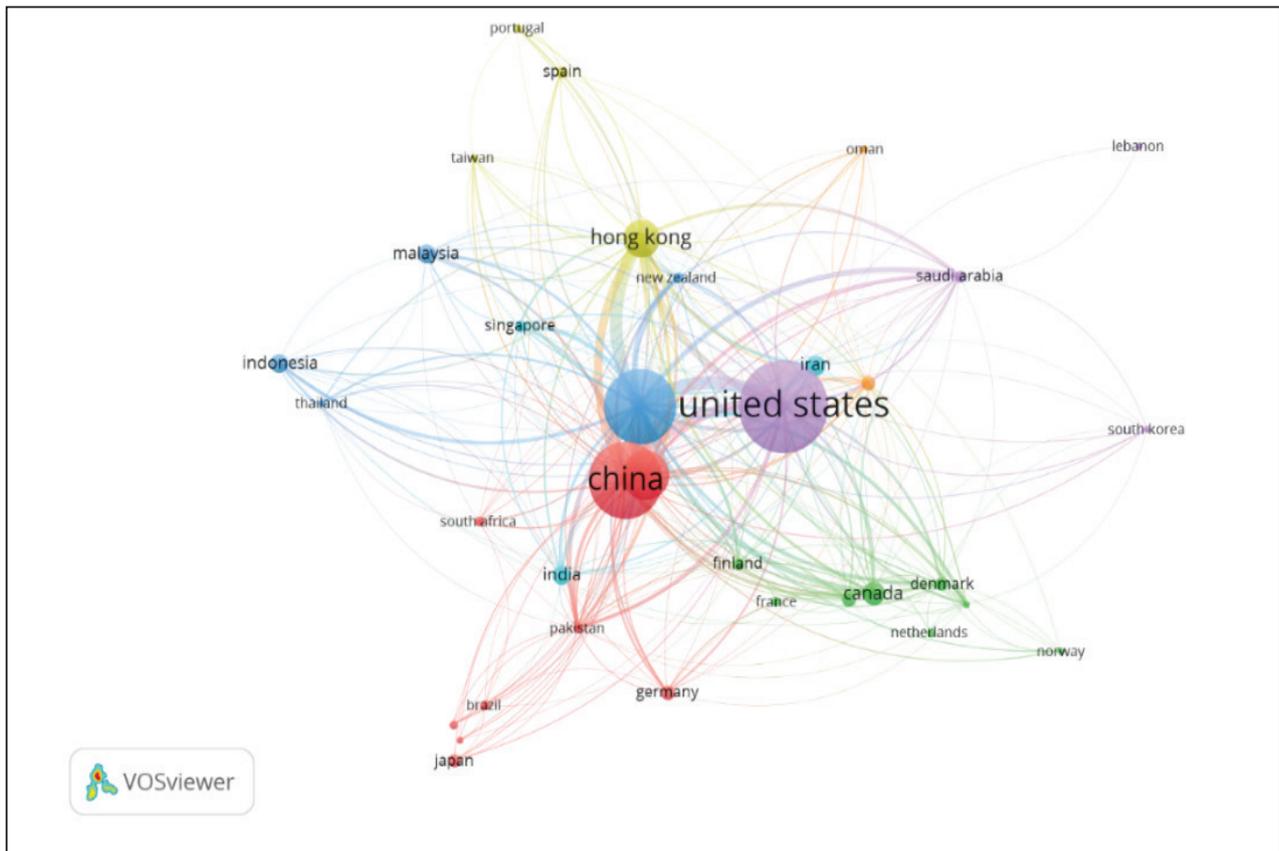


Figure 16: Network visualization of the citation analysis for countries

DISCUSSION

The dramatic increase in research outputs on safety culture in construction industries from 1995 to 2020 is remarkable. This is partially due to the relevance safety culture plays in reducing accident rates in such a sector, as observed by Wamuziri.¹⁵ The upward trend in safety culture research should be seen considering an overall trend in academic publications in related safety topics like construction accident prevention⁴, safety climate.¹¹ However, questions need to be asked if this increasing trend can contribute to construction safety practices. As such, future research can probe on how increasing trends of safety culture research in construction industries can impact their safety practices.

The preference of articles over the conference and other mediums, as observed in figure 3 is due to the low cost and widely available journals on the topic in the literature. According to the website, the Scopus database contains 36,000 titles, and 34,000 are peer-reviewed journals from over 11,700 publishers. In addition, the conventional incentives for publications scheme at various universities worldwide favor research articles over other forms of published

documents in academia. For example, the study by Xu²⁰ reported that the practice of granting incentives for the publication of articles in international journals is widespread in China. Similar reports have highlighted the existence of the practice in many other countries such as the United States, Germany, Denmark, South Africa, and Malaysia, among others.²¹⁻²³ Typically, the publication of articles in peer-reviewed high-impact journals attracts high financial rewards and academic prestige and national awards for researchers. Therefore, researchers must identify and publish in prestigious journals in their fields.

As observed in figure 4, safety science is the journal that published the greatest research on safety culture in the global construction industry. This can be attributed to the massive number of submissions to the journal from worldwide⁴¹. Results from figure 5 indicate that research on safety culture in the global construction industry is multidisciplinary, as evident in the STEM and social science, medicine, and humanities areas where the documents on the topic are categorized in the Scopus database. Furthermore, the findings indicate a vast network of collaborating academics working to address the issues related to the topic in the literature.

The study also sought to obtain insight on top authors, affiliations, countries and organizations working on safety culture in the global construction industry. Results from figures 6,7,8 and 9 show that academics and researchers in institutions in Asia, Oceania US and UK dominated research on safety culture in the global construction industry. The high productivity can be ascribed to enabling environment provided by the institutions based on these countries. For example, studies have shown that the availability of financial support in the form of research grants, knowledge centers, scientific equipment, among others, are critical to the success of any scientific endeavour.^{29, 31} However, research from Africa and South America is lacking which can be an area of future studies.

Another insight concerns co-authorship; as per results from figure 10, a high network of collaboration which is seen in the blue cluster was mainly due to the work of Dongping Fang (Tsinghua University, China), which indicates the author is not only the most published author (with 23 published documents) but also the most prominent researcher (most collaborations) on the topic in the literature. Further analysis revealed that the brown cluster (Helen C. Lingard) has the second-highest connections and link strengths on the map. As revealed earlier, the research work of HC Lingard of RMIT Australia has produced 16 published documents along with APC Chan of (HKPU, Hong Kong). However, the latter cluster has fewer collaborations than the former. In general, it can be surmised that the research output on the topic could also be ascribed to active intra- or international collaborations among the top researchers.

Reflecting on the results from figure 11, The network visualization of country-based co-authorship analysis on safety culture in the global construction industry shows that the United States has the most collaborations. This is to be expected as the US has the most published documents (Figure 8), as reported earlier. Furthermore, there are strong links or collaborations between the United States and other nations like China, Australia, the United Kingdom and Hong Kong. However, the most robust inter-nation links are between Australia and China as shown in the thick line or link between the two countries, which is due to the links between the research works and publications of Fang D, Lingard H and Feng Y. In addition, there are strong links also exist between the United Kingdom and Hong Kong as well as between Australia and Indonesia

based on the research collaboration and citations of the researchers located in these countries.

Additionally, results from figure 12 show the network visualization map on the co-occurrence of author keywords on safety culture in the global construction industry. As observed, the most co-occurrent author keywords on the topic are safety culture, safety performance, and construction industry, which is to be expected due to the search query used in the study. The search was based on the occurrence of a keyword at least 3 times in the search query results, which resulted in 1320 keywords, of which 133 keywords fulfilled the selected criteria. Hence, the total number of clusters generated was 16 based on the co-occurrent keywords. In contrast, the index keywords generated 9 clusters based on based a minimum occurrence of a keyword 3 times.

Findings from figure 13 indicates that the selection of index keywords on safety culture and the construction industry is very broad and multidimensional but related to the health and safety of workers in the industry. According to analysis, the construction industry is one of the most accident-prone in the world, with numerous reported cases of injuries and fatalities annually. Hence, numerous studies are conducted annually to proffer cost-effective, socially acceptable, and environmentally sustainable strategies to safeguard human health and safety on construction worksites around the world. The index keyword analysis also shows that various innovative tools and research methods (such as multivariate analysis, questionnaires, neural networks, least-squares approximations, resilience reengineering, factor analysis, structural design, and cross-sectional studies) have been employed to research the topic. Based on the findings, many safety policies, strategies and measures have been proposed over the years.

Based on Figures 14-16, it can be reasonably surmised that the authors, journals, and countries have garnered significant citations over the study period examined in the study. Notably, the research works of Fang D, Lingard H, Chan APC, Feng Y, Sunindijo RY, and Latief Y have been cited significantly, which confirms their immense scholarly contributions to the topic over the years. Figure 14 also confirms the research impact and high collaboration rate between the top researchers. Figure 15 also confirm the scholarly importance and research impact of the journals Safety Science, Journal of Safety Research and the Journal of construction

engineering and management to the field. The documents published by the aforementioned journals have garnered the highest citations and co-citations over the years. The most robust links and co-citation also exist amongst the three journals earlier reported as the most prolific on the topic. On a country basis, the United States, China, and Australia have the highest citations. Overall, the findings indicate that co-citation among nations is also high, particularly between the US and the other top countries, China, Australia, and the United Kingdom.

CONCLUSIONS

The study examined the research trends on safety culture in the global construction industry using bibliometric analysis techniques. Based on the PRISMA, published documents published by various journals indexed in the Scopus database were identified, screened, and analyzed based on the period from 1995 to 2020. The designed search query executed in the Scopus database returned 738 documents comprising articles, reviews, and conference proceedings, among others. The resulting data were subsequently analyzed through VOSViewer software to uncover the latest research trends on the topic based on the co-authorship, keyword co-occurrence, and citation analyses. The

findings showed that articles are the preferred type of publication for most authors in the field, whereas Engineering is the most frequent subject theme for published documents. The most prolific authors working on the topic are based in China, Australia, and Indonesia, which indicates that researchers in Asia and Oceania are dominant in the field. However, the United States, China and Australia have published the most documents on the topic over the period under examination, which could be attributed to the availability of financial support typically in the form of research funding, knowledge centers or intellectual exchanges. Bibliometric analysis showed the existence of large networks of researchers, organizations and countries that have collaborated on various studies and published highly cited documents over the years. The large clusters of co-authors, occurring keywords and citations indicate that the topic of safety culture and the construction industry has a significant research impact. The global importance of the topic can be attributed to its role in safeguarding the health and safety of workers in the global construction industry. The study findings provided comprehensive information on the research landscape and scientific developments which could be helpful to future researchers, industries, and policymakers looking for an overview of the topic or quick data to make decisions, and find collaborators or even funders for their research.

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