Migration Letters

Volume: 21, No: 3, pp. 1027-1044

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)
www.migrationletters.com

Bibliometrics Analysis of Occupational Health and Safety Construction: Trend Research during Pandemic (2019-2022)

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Abstract

Occupational Health and Safety (OHS) becomes an important thing in every sector of work, not least in the construction sector which is reported to be the sector that dominates the number of work accidents compared to other sectors. In addition, in the last two years the Covid-19 diseases appeared as a global phenomenon that spread throughout the world and affected the global economy stability, including in construction sector which further treated Covid-19 as a hazard. This study will provide an overview of OHS construction research by updating the reference year and searching data using search strategies according to the topic through the Scopus database. The bibliometrics analysis was used to retrieve 1,060 publications between 2019 and 2022. These years used in order to find out how the Covid-19 affected to the OHS construction publications. This study shown that the publication and growth trends has the increasing number of OHS publications from each year with Asia was leading the publications, followed by Europe, America, Africa, and Australia. There are also the visualizations through co-occurance keywords using VOSviewer and direct five-theme of OHS study, namely OHS technology advancement, OHS sustainability, OHS prevention through Covid-19, OHS environmental impact, and OHS evaluation. One of the exciting things is the emergence of the Covid-19 pandemic phenomenon, which is a new beginning for changes in the field of occupational health and safety. US and China have a high research development productivity, primarily through the Covid-19 phenomenon that emerged from the China and US has the highest number of cases and deaths, increasingly making the country the center of attention. This certainly opens up opportunities in the future for the implementation and regulation of OHS considering the covid-19 phenomenon for better OHS implementation.

Keywords: *occupational health and safety, bibliometrics analysis, covid-19, pandemic, construction.*

1. Introduction

Occupational Health and Safety (OHS) is an important thing that cannot be ignored in the work environment and has become a fundamental point and strategic element in every sector of work, starting from the subject of medicine, science, engineering, social sciences, etc [1]. Basically, every company has the same concern for the health and safety of their workers. The safety performance of a company also represents the company's commitment and brand values which are considered to depend on safety culture, human factors, and employee behavior [2], [3]. Regarding to the importance of OHS,

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International Labor Organization has recorded more than 2.78 million deaths occur annually due to work accidents [4]. Globally, the construction sector dominates the number of work accidents because it has a higher level of potential hazards and fatal injuries than other sectors [5], considering the work environment is always related to the construction equipment, both heavy equipment and other supporting equipment [6].

In addition, in the last 2 years the number of deaths has increased significantly due to the Covid-19 epidemic that has spread throughout the world and was declared by WHO as a pandemic in March 2020 [7]. Since its appearance until now, Our World in Data as of July 6th 2022 presents statistical data on Covid-19 and has accumulated the number of Covid-19 cases worldwide reaching 551 million cases with a death rate of 6.3 million deaths. This phenomenon has a major impact on global economic stability, including in the construction sector [8]–[10]. The construction sector itself treats the Covid-19 as a hazard [11], so that the appearance in this sector is closely related to the strategy and implementation of OHS protocol that was developed effectively to respond and adapt to this condition [12]–[14]. Various forms of OHS construction responses to Covid-19 include: safety regulations and procedures [13], [15], working model in construction area [16], risk evaluation and hazard control [12], until the optimizing technology to identify and monitor hazards during a pandemic [15], [17]. Modifications and adjustments to the OHS implementation which carried out to pandemic condition must be able to give contributions in reducing the negative consequences and mitigating the risk of spreading Covid-19 in the work area [18], [19].

By seeing the growth of research in the last few decades, academics and practitioners have conducted many OHS studies in the construction sector regarding to safety design as an effective innovation to identify and minimize the hazards and risks in the work area [20], [21]. In its journey, recently research on OHS construction has begun to prioritize continuous improvement by involving the latest technology [22] in making comprehensive and integrated OHS analysis frameworks [23], [24]. The utilization of information and communication technology tools is a form of digital transformation in construction in order to improve management processes, including OHS management [25]. The mentioned technology in the OHS construction studies more or less refers to a safety risk assessment by identifying the potential hazards from the beginning [26]. This technology in OHS is become the continuous spotlight [27] as well as attracting researchers and practitioners to contribute in creating the effective, efficient, and high-quality of work management especially in construction sector [28].

An overview of the trend research on safety design in construction with a technology focus has been conducted by Che. [29] which were analyzed by scientometric analysis with a quite long span of years (1974-2022). The results of this study show that the publication on safety design that are most cited are articles with a focus on the integration of safety and BIM concept. In addition, the authors were also provide predictions for future research on safety design with several themes including: concept and managements, technological advancement, capability and competency, education, and sustainability. In the time framed mentioned, the overview given regarding to the safety design looks comprehensive, but has not mentioned the global phenomenon that occurred between 2020-2022, namely Covid-19 and pandemic. Beside that, another study was conducted by Luo. [30] who also provide an overview of construction safety research trends over a 10 years span from 2010-2020. The results of this study show that the safety management and safety climate are the main topic area in OHS construction. However, the limitation of the study year span which is only until 2020 is become a gap in how the growth and trend of OHS construction publication where the global phenomenon Covid-19 occurs in the following year. It is necessary to renew the reference year that can describe relevance of global phenomenon to the publication of OHS construction.

This study will provide an overview of OHS construction research by updating the reference year and searching data using search strategies according to the topic through

the Scopus database. The range of years used is 2019-2022 to see how the global phenomenon Covid-19 has changed the publication and growth trends of OHS construction study. In addition, this study will also provide predictions future research of OHS construction using visualization of Vosviewer software and see the novelty possibilities that will arise. This study is expected to contribute to creating the work environment which is more adaptive and preventive towards the safety workers through the better implementation of OHS.

2. Methodology

2.1. Bibliometrics Analysis

Bibliometrics is a quantitative descriptive-based study approach method through collecting data from various databases [31], [32]. There are two main phases in bibliometrics analysis, namely collecting the general statistic data and mapping and cluster analysis using the Vosviewer software [33]. Bibliometrics analysis is an effective way to provide high-level insight regarding to the characteristics of the number of publications in a particular research domain [34].

In this study, the data was collected by using Scopus database and Publish or Perish software which is then statistically processed by Microsoft Excel to find out the annual publication and growth trends as well as the tables/graphics to be presented [35]. Through the Scopus database, the data collected were 2,255 publications using a tile-abs-key search strategy related to the OHS construction topic. Scopus was chosen because it has articles with a wider multidisciplinary distribution, more comprehensive bibliometrics data, high-rate of novelty of articles publications, and better credibility [36].

Furthermore, the data is entered into Vosviewer software to obtain advance visualization by displaying data such as clustering analysis, citation analysis, co-citation analysis, co-author analysis, co-occurances keywords, etc [37]. The display of the distribution data visualization in this software divided into 3 visualizations, namely network visualization, overlay visualization, and density visualization. The visualization of network and overlay will formed bubbles according to the research dominance, meanwhile the density visualization will display the distribution of research based on the color density. The higher the publication level, the area will display the yellow color, while the lower of publication level the color will tend to be blue to dark blue [38]. The color clustering and descriptions that appear in each visualization can be used to identify the level of novelty in the research being carried out and predict the future publication trends [39].

2.2. Literature Screening

This study adopts a 4-step literature approach by Mustaffa. [40] which consists of (Fig.1):

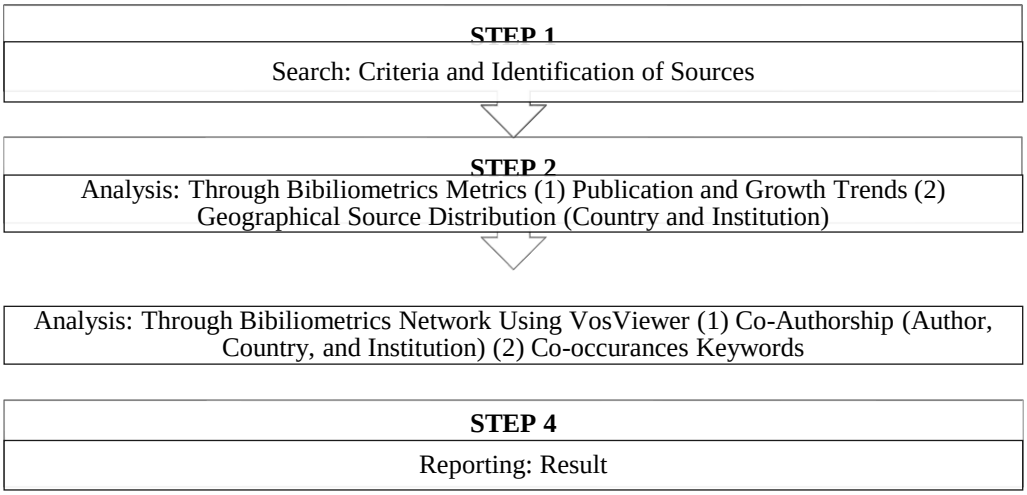

Figure 1. Systematic approach of the research

Step 1. Determine the criteria and identify the source used. Existing articles of OHS construction were collected through Scopus database using Title-Abs-Key as follows: "occupational health safety" or "health safety" or "health safety construction" or "safety construction". The data obtained will be screened by the relevant subject area. After the data set, it will be entered into Publish or Perish first to find out the details of citation metrics, then exported to Microsoft Excel for data processing in the next step.

Step 2. Bibliometrics analysis through the (1) Publication and Growth Trends and (2) Geographical Source Distribution (Country, Institution, Author) after the data were set. This analysis is conducted by using Microsoft Excel to present the data in the form of tables/graphics according to the needs of research. The graphics used to illustrate the publication and growth trends of research from 2019-2022, while the tables used to present the data of the most influential country, author, and institution regarding to the OHS construction publication in the range of years mentioned.

Step 3. Bibliometrics analysis using Vosviewer map-network through Co-Authorship (Author, Country) and Co-occurrences Keywords. This analysis will visualize the network which is divided into 3 visualizations, namely network visualization, overlay visualization, dan density visualization. The formed of network visualizations in this Vosviewer software can identify the level of novelty in research conducted as well as the prediction of future research. This analysis will appear the global phenomenon of COVID-19 through the co-occurrence keywords.

Step 4. Reporting the results. As explained in step 2 and step 3, the results will consist of; (1) Publication and Growth Trends; (2) Top 10 Subject Area; (3) Top 10 Country; (4) Top 10 Affiliation; (5) Map Network: Co-authorship, country, institution; (6) Map Network: Co-occurrences Keywords.

Table 1. Searching Strategy and Retrieval Process

Date	: July 12th 2022
Database	: Scopus
Searching Strategy	: Title-Abs-Key "occupational health safety" or "health safety" or "health safety construction" or "safety construction"
First-stage Screening	: 2,255 publications (2019-2022)
Second-stage Screening (set relevant subject area)	: 1,060 publications

After set the relevant subject area in the range of year 2019-2022 using Title-Abs-Key searching startegy (Table 1), the Scopus database covers 1,060 OHS construction publications. This final results exported to the Microsoft Excel in comma-separated value (CSV) and Research Information System (RIS) formats. Publish or Perish software also involved regarding to show the citation metrics (Table 2) of the OHS construction publications.

Table 2. Citation Metrics

Reference Date	: July 12th 2022
Publication Year	: 2019-2022
Citation Year	: 3
Paper	: 1060
Cite/Year	: 1464.67
Cites/Paper	: 4.15
Cites/Author	: 3.82
h index	: 25
g index	: 42

3. Result and Discussion

3.1. Publication and Growth Trend

Publication and growth trends in the bibliometric analysis are essential to be presented to see the trend of research development on the topics raised [41]. Fig. 2 contains graphic information on publication trends and the number of research citations regarding the construction OHS in the 2019-2022 range. The number of publications in 2019 was 249 publications with a total of 1,952 citations. The number of publications in 2019 accounted for 23.49% of all publications collected. In 2020, the number of publications increased to 268 (25.28%), totaling 1,315 citations. Furthermore, there was significant growth in 2021, namely 363 publications (34.24%) and as many citations as many as 1,023. In 2022, the number of publications will be 176, totaling 104 citations. The total accumulated publications from 2019-2022 based on the relevant subject area are 1,060 publications with a total of 4394 citations.

Publications have increased from 2019-2021 (n=631), which, if accumulated, is as many as 880 publications. Considering the timing of the research carried out in mid-2022 and the growth of research in previous years, it is possible that research growth in 2022 will still increase in the number of publications.

Meanwhile, the total citation data from 2019-2021 has decreased significantly. Citations are an essential component of behavior related to scientific research because they measure the scientific impact of a publication [42], so that the decrease in citation rates each year becomes a picture of researchers' interest in the topic raised, more specifically, the keywords used. It can be used to see potential areas for further theory and methodology [43].

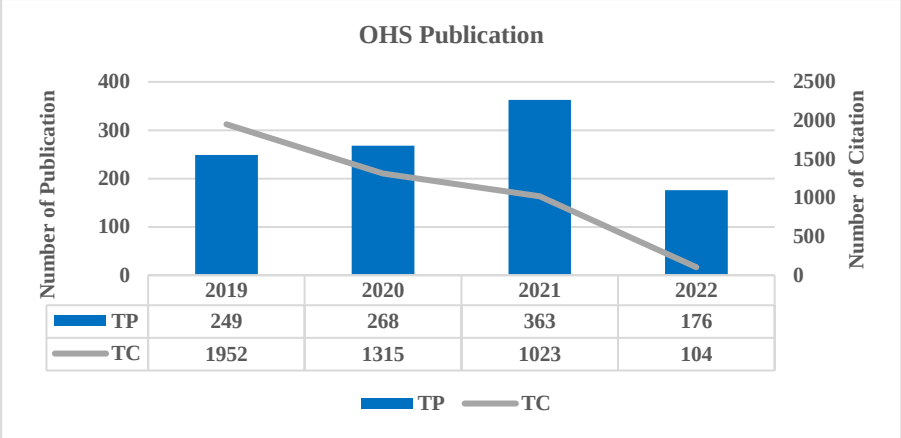

Figure 2. Annual growth of OHS publications and total citations, Scopus 2019-2022 (n=1,060)

Publication documents are also determined from the type of document and language (Fig. 3) used in the construction OHS article. Figure 3a. provides information on the number of distributions of 9 types of construction OHS publication documents in the form of pie charts consisting of articles (n=667; 62.92%), conference papers (n=236; 22.26%), reviews (n=80; 7.55%), book chapters (n=52; 4.91%), books (n=14; 1.32%), notes (n=4; 0.38%), erratum (n=3; 0.28%), data papers (n=2; 0.19%), and conference reviews (n=2; 0.19%). Fig. 4 presents a graph of the language used on the construction OHS publication document. English is the most widely spoken language at n=1061 (95.22%), followed by Chinese at n=19 (1.78%).

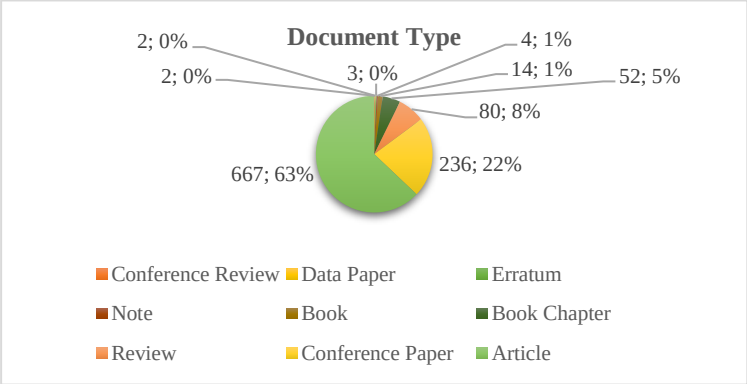

Figure 3. Document type of OHS publications

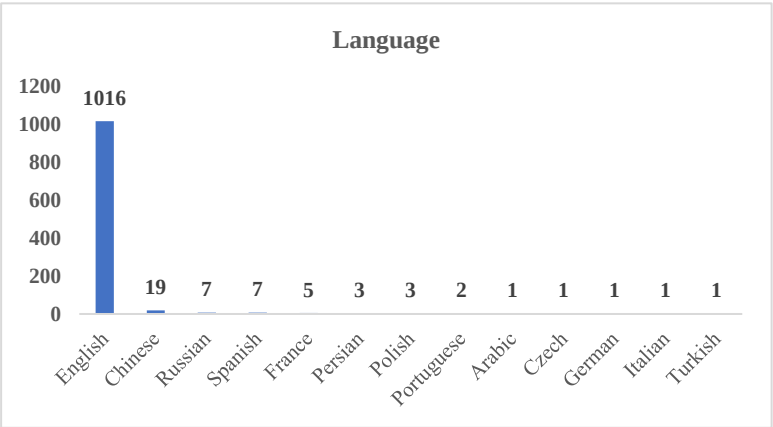

Figure 4. Language of OHS publications

Unlike the other databases which is categorized the publications into major subject area, Scopus categorized the publications into many subject areas which are broken down in more detail and focus [44]. The following table 3 below present the top 10 of the distribution publications in subject area for each year (2019-2022). Referring to the search strategy used in this study, the construction sector will be related to the subject of "Engineering" and "Environmental Science", so that the articles in these two subjects definitely dominate the number of publications. Especially in "Engineering", the number of publications is in high number and quite big differences compared to other subject areas. This subject covers 540 publications, followed by "Environmental Sciences" which covers 369 publications and "Social Sciences" which covers 340 publications, while other subject areas have a total number of publications under 200 publications.

Based on table 3 below, subject "Engineering". "Social Sciences", "Medicine", "Energy", and "Business, Management, and Accounting" has a constant number of publications growth from 2019 to 2021. Overall, this distribution allows us to see the degree of research conducted on a particular subject over time and can help in identifying issues to more focus [40].

Table 3. Top 10 Subject Area

Subject Area	Year				TP
	2019	2020	2021	2022	
Engineering	136	147	160	97	540
Environmental Science	84	83	142	60	369
Social Science	66	98	123	53	340
Medicine	34	44	56	29	163
Computer Science	42	29	50	20	141
Energy	25	37	42	12	116
Earth and Planetary Science	29	20	37	12	98
Business, Management, and Accounting	23	25	29	11	88
Agricultural and Biological Sciences	26	15	22	11	74
Material Science	6	27	26	11	70

3.2. Geographical Source Distribution by Country, Institution, and Author

Based on data publications collected by Scopus database, the documents contain 23 undefined countries, no ambiguous institutions, and 6 unclear author (100% author). This study defines 94 countries with a total number of publications 1353 publications, exclude undefined countries (n=23). This number of publications is over 1060 publications considering the possibilities of the collaboration of authors and 1 or more author who live in multiple countries. The worldwide distribution of OHS construction publications shown in Fig below. Asia was leading the number of publications consists of 32 countries (n=471; 34.81%) with top 5 country starting from China (n=141), India (n=78), Iran (n= 38), Malaysia (n=28), and Indonesia (n=25). Then, followed by Europe which consists of 33 countries (n=453; 33.48%), America which consists of 8 countries (n=279; 20.62%), Africa which consists of 19 countries (n=86; 6.36%), and Australia which consists of 2 countries (n=64; 4.73%).

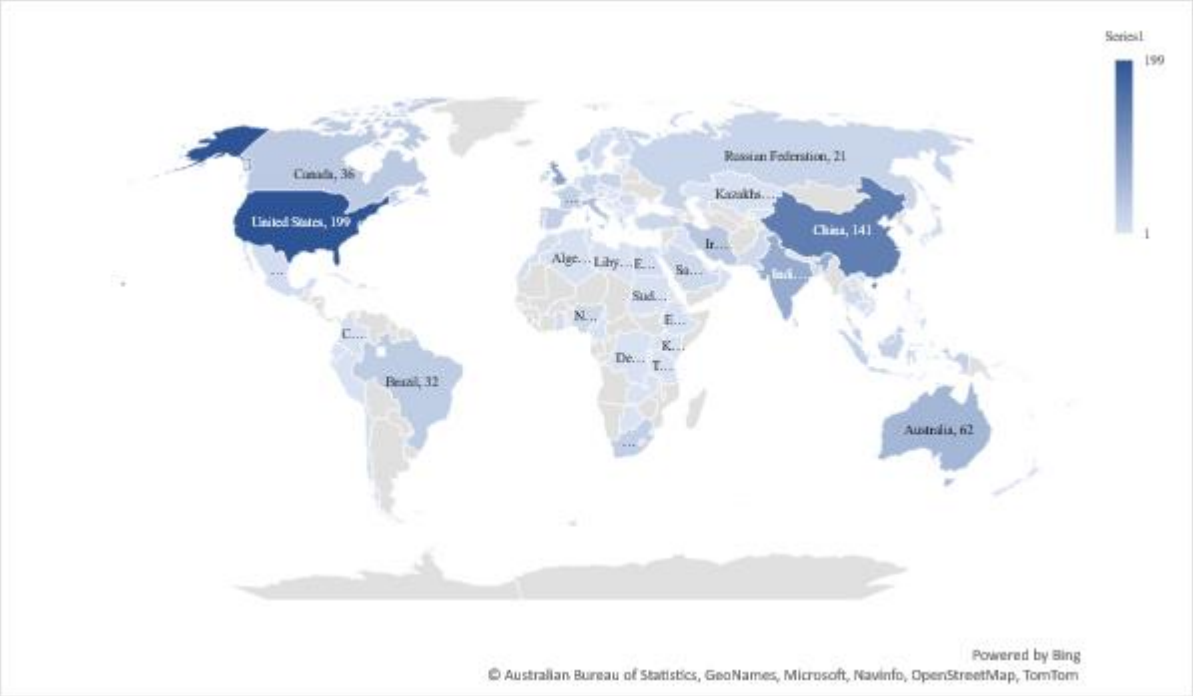

Figure 5. Distribution of OHS Publication by Country

Table 4. below shows the top 10 countries that contributed to the number of construction OHS publications collected, with an estimated 55% of the total publications. In total, 94 countries (except undefined countries) contribute to the construction of OHS publications, 50 countries have 5 or fewer publications, 26 countries have between 6-20 publications, and 18 other countries have a publication count above 20 publications. The most publications came from the United States (n=199; 14.46%) and were followed by China (n=141; 10.25%), and the United Kingdom (n=93; 6.76%). Like the United Kingdom, other countries account for publications with a percentage below 10%.

Table 4. Top 10 Country

COUNTRY	Total Publication	%
United States	199	14,46%
China	141	10,25%
United Kingdom	93	6,76%
India	78	5,67%
Australia	62	4,51%
Italy	50	3,63%
Iran	38	2,76%
Canada	36	2,62%
Brazil	32	2,33%
Norway	29	2,11%

Table 5. shows the top 10 institutions that contributed to publications on construction OHS during 2019-2022. Institutions from China ranked first and second, namely the Chinese Academy of Sciences and Ministry of Education, with the highest number of publications (n=13 and n=10), followed by institutions from South Africa, namely the University of Johannesburg (n=9). Other institutions account for publications under ten publications. In total, there are 160 institutions, of which 119 institutions have several

publications of under five publications each, 40 institutions have several publications of 5-10 publications each, and one institution has more than ten publications (n = 13).

Table 5. Top 10 Institution

Institution	Total Publication
Chinese Academy of Sciences	13
Ministry of Education China	10
University of Johannesburg	9
Delft University of Technology	8
Hong Kong Polytechnic University	8
University of Chinese Academy of Sciences	8
University of Illinois at Chicago	8
Universidade Federal do Rio de Janeiro	7
Norges Teknisk-Naturvitenskapelige Universitet	7
Instituto Politécnico do Porto	7

3.3. Map Network: Co-authorship, Country, and Institution

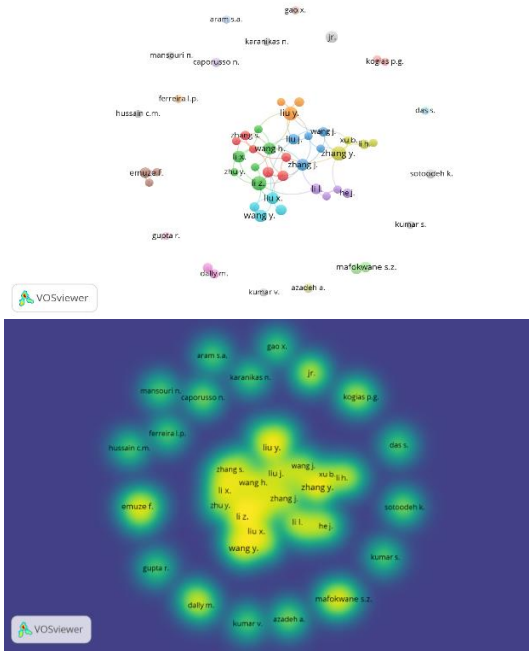

Figure 6. Author co-authorship map; (a) network visualization; (b) density visualization

In the study of occupational health and safety, this study presented several visualizations obtained through VOSViewer software, including an analysis of authors, organizations, countries, and keywords. Each analysis consists of visualization of the work network, visualization of density, and visualization of overlays. The first analysis carried out is an analysis of co-authorship with a concentration on authors. In this analysis, 1060 articles were used, which then netted as many as 3683 authors using a minimum number of documents of an author as many as three and a minimum number of citations of an author 0 so that the number of authors netted was narrower as many as 55 authors. Fig. 6

presents detailed names – author names per cluster marked with different colors of each cluster. In addition, there is also a network relationship between inevitable bubbles which means the relationship between one bubble and another. In this co-authorship analysis, 55 items, 25 clusters, 71 links, and 87 total link strengths were produced.

Fig. 6 above displays a network visualization analysis of the co-authorship mapping that has been carried out. The visualization shows that authors from the country include Wang g., y., Zhang s., Zhang y., and Cao y. pioneered, and Liu h., on cluster 1, Chen t., Li x., Wang h., Zhang h., Zhu y., which was pioneered by Li z., on cluster 2, Liu j., Wang l., Wang j., Wang j., Zhao x., pioneered by Zhang j., on cluster 3, Xu b., Li h., Luo x., spearheaded by Zhang y., on cluster 4, Guo y., Sun y., He j., pioneered by Li l. on cluster 5, Wang f., Li j., which was pioneered by wang y and Liu x. on cluster 6, and Chen y., Chen z., which Liu y. pioneered on cluster 7. has a dominant network distribution. This shows that collaborative activities between authors in the country are running very well and shows the existence of sustainable research productivity. While the distribution of authors in other countries does not have as much linkage as the relationship between Smallwood j., Mollo l., which Emuze f. pioneered on cluster 8 and Newman l.s, Dally m. in cluster 9, the rest have no linkage between each other. This can be identified as a research development that tends to be individualist. In addition to visualization of the network, analysis is also carried out by looking at density visualization, where the brighter the author's name can be identified, the productivity and research collaboration show a stronger level of development while the darker it shows the opposite.

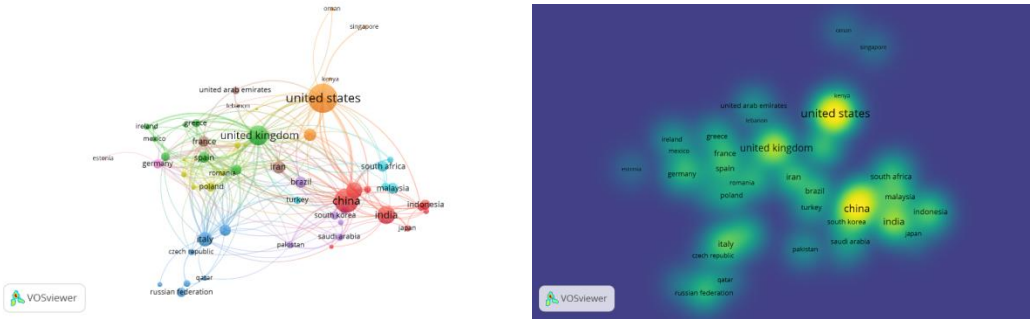

Figure 7. Country co-authorship map; (a) network visualization; (b) density visualization

The following analysis is related to the distribution of the country. From the 1060 articles used, 115 countries were then focused on again, with the minimum number of documents of country three and the minimum number of citations of country 1. In addition, countries that do not have links are not included in the visualization, so as many as 57 countries are obtained, divided into 9 clusters, 286 links, and 470 total link strength.

Fig. 7 shows that the Americans in cluster 7 are symbolized by the color orange being a country with a bubble circle that is dominant among others. This condition can mean that research related to occupational health and safety in the country contributes to many research figures. The country is in a cluster with Canada, Kenya, Oman, and Singapore, which means the country is a supporting country in co-authorship. The thickness of the network line describes a strong level of collaboration between countries. For example, the thick line on the American bubble leads to the UK and China. This means that the authors in various institutions in America have a relatively high level of research collaboration with authors in the UK and China. They were followed by Norway and Italy, which are depicted with not-too-thick lines describing the research collaborations that were built not as strong as those of the United Kingdom and China to the Americans.

Overall, the study of occupational health and safety in the world was pioneered by several countries supported by strengthening research through collaboration, including the Americans, mentioned above, China, The United Kingdom, India, and Australia. Visualizing the density of countries with a density of light color (yellow) can be

interpreted as the pioneer countries of OHS research. While the darker the color of a country's density, it can be categorized as a research support country in each cluster through co-authorship. In addition, this can also be interpreted to mean that the research carried out in these countries is still not collaborative and productive.

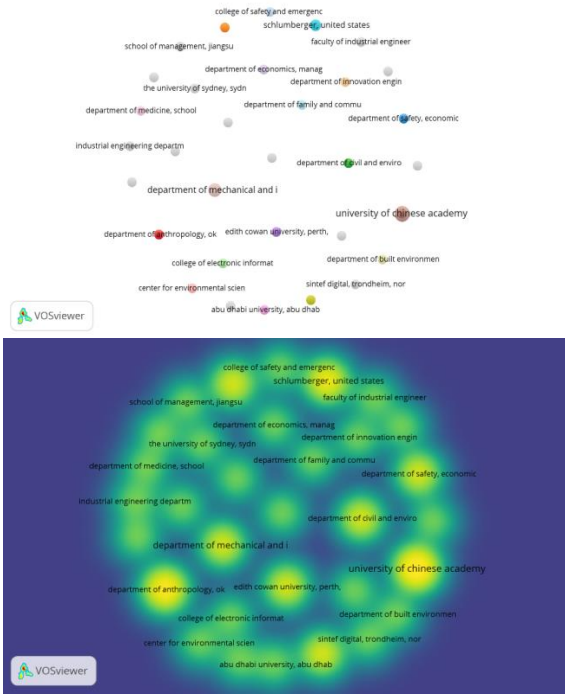

Figure 8. Institution co-authorship map; (a) network visualization; (b) density visualization

Next is the visualization of organizations related to OHS research. In this section, an analysis is carried out by including the minimum number of documents of an organization and the minimum number of citations of an organization 1. Of the 2459 organizations detected, 41 organizations complied with the provisions, 32 clusters, ten links, and 19 total link strengths. Based on Fig. 8, the largest bubble fell to the University of Chinese Academy. When linked to the analysis of some of the previous aspects, China occupies a superior position in developing OHS research. One of the supports comes from universities as research providers. The same can be seen from the visualization of density, where the university gets the brightest color frequency.

3.4. Map Network: Co-occurances Keywords

The mapping in this VOSviewer below (Fig. 9) reflects the keywords used by the author. In this study, several keywords were used: occupational health safety, health safety construction, health safety, and safety construction. In this visualization, a giant bubble symbolizes the level of popularity, while a small one symbolizes a keyword that has not been widely researched. So from there, we can see various phenomena that have not appeared much to be studied for novelty. In addition to the size of the bubble, analysis can also be done through stacking between one key and another keyword, where the closer the relationship between keywords, the stack between the bubble, the tighter it is. This visualization obtained 466 items, 7 clusters, 16805 links, and 31630 total link strength.

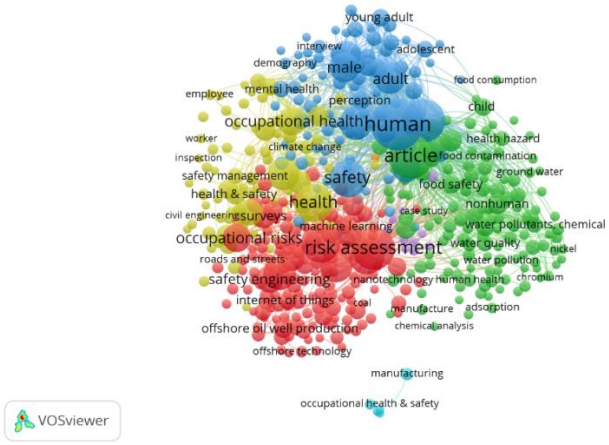

Figure 9. Co-occurance keywords

Through visualized data, research on humans, risk management, and health has become an important topic that is widely researched. In addition, there is a novelty of themes that in previous studies have not yet appeared related to COVID-19, which is spread across several clusters, namely clusters 1, 3 and 5. Here is the clustering of networks denoted by the difference in the color of each bubble:

Cluster 1. Visualization of Occupational Health and Safety research in cluster 1 consists of several distributions of keywords denoted by red, namely: artificial intellegence, augmented reality, building information modelling, emerging technologies, virtual reality, etc.

Cluster 2. Visualization of Occupational Health and Safety research in cluster 2 consists of several distributions of keywords denoted by green, namely: chemical analysis, environmental pollutant, human health, nanoparticles, toxicity, etc.

Cluster 3. Visualization of Occupational Health and Safety research in cluster 3 consists of several distributions of keywords denoted by dark blue, namely: covid-19, epidemic, isolation, pandemic, social distancing, viral desease, etc.

Cluster 4. Visualization of Occupational Health and Safety research in cluster 4 consists of several distributions of keywords denoted by yellow, namely: accident, building industry, management, law and legislation, regulations, workers, etc.

Cluster 5. Visualization of Occupational Health and Safety research in cluster 5 consists of several distributions of keywords denoted by purple, namely: air quality, atmospheric pollution, health impact, particulate matter, pollution control, etc.

Cluster 6. Visualization of Occupational Health and Safety research in cluster 6 consists of several distributions of keywords denoted by green, namely: hydraulics, internal combustion engine, manufacturing, material handling system, occupational health and safety.

Cluster 7. Visualization of Occupational Health and Safety research in cluster 7 consists of several distributions of keywords denoted by the color orange, namely: psychology, and safety measures.

Based on the cluster above, this OHS study directs five themes which can be used to highlight OHS research: (a) OHS technology advancements; (b) OHS sustainability; (c) OHS prevention through Covid-19; (d) OHS environmental impact; and (e) OHS

evaluation. These themes can also be used to direct future research pf OHS construction. The explanation of each identified theme is discussed further below.

OHS Technology Advancements

Along with the times, research trends related to work accidents lead to the development designs and prevention methods [29], [45]. One of the safety designs in work that has recently been widely studied is DfS (Design for Safety) [46].

The design of the application of OHS in the field through DfS shows that there is better integration of technology and prevention efforts against the risk of work accidents, for example, such as the application of Building Information Modeling (BIM) [47], [48] already mentioned in the background. However, in reality, the use of this system is not comprehensive in every construction sector [49]. So there is still a chance of work accidents in other construction sectors. The existence of job accident opportunities in the construction sector that have not been digitized creates a gap that is worthy of further research. This aims to get predictions for the implementation of OHS in the future. Especially since the Covid-19 pandemic demands massive changes [9], this factor will significantly affect the implementation of OHS in the future.

OHS Sustainability

The implementation of sustainability and sustainability of the work environment is divided into three pillars: people, planet, and profit [50]. The three are interrelated, for example, in the case of work accidents that require companies to spend money as a form of loss [51], while the inefficiency of workers due to accidents results in poor performance so that the work process cannot run optimally and of poor quality [52]. If this happens during an intense time, it can affect the company's good name [53] which impacts the unsustainability of the company's operations.

According to the ILO (International Labor Organization), OHS impacts the fulfillment of Sustainable Development Goals number 3, which aims to ensure a healthy life and improve the welfare of every individual of various ages. This is strengthened through SDGs point number 8, which aims to promote inclusive and sustainable economic growth, job creation, and decent work for all, and SDGs number 16, which aims to promote a just and inclusive society [54]. To realize these points, OHS is a form of protection, effort, and prevention of workers in the company environment so that the OHS sustainability trend attracts the interest and concentration of researchers in more depth. They are supported by changes in world conditions due to the Covid-19 pandemic, which provided significant changes in the sustainability of the OHS system in every job sector, including construction.

OHS Prevention Through Covid-19

The Covid-19 disease that spread all over the world and give an impact on all industrial sector, including construction sector, has attracted attention because it contributed to the high-rate of deaths in the last two years. There are some of challenges for the construction industry due the Covid-19 pandemic include: health and safety on-site, economic cost, possible legal exposures, manpower availability, instability of the supply chain and subcontractors, and the uncertainty related to the constant and unpredictable evolution of the pandemic [55]. The OHS management system is important to be implemented in order to prevent the spread of Covid-19 disease in the workplace [56]. The implementation mentioned must include new safety measures adopted to respond the Covid-19 challenges in construction industry [57]. This is also related to the technology advancements, where the use of technology in construction can be remotely monitoring the workplace, thus avoiding direct contact which can affect the spread of Covid-19 itself.

OHS Environmental Impact

OHS has a significant impact on the environment. The implementation of OHS provides a regulatory space for the implementation of safety in the workplace, which will indirectly affect the orderliness of the environment. Such as the use of procedurally organized chemicals will create regularity in working to minimize the negative impacts that will arise [58]. In addition, it will impact the environment, namely, creating a healthy environment because its components are not polluted. So because of the element of sustainability for the environment, this topic has become a trend that is widely researched about one of the points in the 17 goals to be achieved in the SDGs.

OHS Evaluation

Evaluation is critical in measuring the frequency level of work accidents. Based on the search results from the Scopus database that have been carried out by researchers related to occupational health and safety topics, some of the assessment forms discussed are the development of models, assessment methods, and data collection techniques. One application of the model is PFSs (Picture Fuzzy Sets), a systematic approach that measures differences in measurement and decision making. So, this model can also be used to effectively identify critical work hazards and improve the working conditions of workers.

In addition to the assessment model, in the research conducted by Koulinas [59] there is a Fuzzy TOPSIS assessment technique that aims to establish risk priorities in the workplace to promote the health, safety, and well-being of workers, issues embedded in the concept of sustainability based on similarities with ideal solutions, in particular, those that fall within the scope of social sustainability. Then the multicriteria method cooperates with a simple quantitative risk analysis and assessment process; the balanced risk assessment (PRAT) technique has a function that is based on accurate data. Effective PRAT is used in evaluating occupational health and safety. Another step in evaluating occupational health and safety implementation in each job sector is to use pre-test and post-test methods. This is done to obtain comparative results from experiments with one another [60].

4. Conclusion

Occupational Health and Safety (OHS) is an important thing that cannot be ignored in the work environment and has become a fundamental point and strategic element in every sector of work. From the 1,060 publications collected by Scopus database between 2019-2022, the publication and growth trends shown the increasing number of OHS publications from each year with Asia was leading the publications, followed by Europe, America, Africa, and Australia. There are also the visualizations through co-occurrence keywords using VOSviewer and several keywords were obtained indicating a gap in novelty that can be analyzed about occupational health and safety. This study direct five-theme of OHS study, namely OHS technology advancement, OHS sustainability, OHS prevention through Covid-19, OHS environmental impact, and OHS evaluation. One of the exciting things is the emergence of the Covid-19 pandemic phenomenon, which is a new beginning for changes in the field of occupational health and safety. From the results presented above, US and China have a high research development productivity, primarily through the COVID-19 phenomenon that emerged from China and US has the highest number of cases and deaths, increasingly making the country the center of attention. So the excavation of research is considered the first step of any ongoing changes to be carried out, this certainly opens up opportunities in the future for the implementation and regulation of OHS implementation in every job sector by using the covid-19 phenomenon as a stepping stone for better OHS implementation.

Acknowledgement

This paper was made to fulfill the writing of dissertation and a form of collaboration with other universities. Thank you to the academic community who have supported the writing of this paper properly.

References

[1] R. Sharma and D. K. Mishra, "An analysis of thematic structure of research trends in occupational health and safety concerning safety culture and environmental management," Journal of Cleaner Production, vol. 281. Elsevier Ltd, Jan. 25, 2021. doi: 10.1016/j.jclepro.2020.125346.

[2] L. Morgado, F. J. G. Silva, and L. M. Fonseca, "Mapping occupational health and safety management systems in Portugal: Outlook for ISO 45001:2018 adoption," in Procedia Manufacturing, 2019, vol. 38, pp. 755–764. doi: 10.1016/j.promfg.2020.01.103.

[3] F. H. Ali, F. Liaqat, S. Azhar, and M. Ali, "Exploring the quantity and quality of occupational health and safety disclosure among listed manufacturing companies: Evidence from Pakistan, a lower-middle income country," Safety Science, vol. 143, Nov. 2021, doi: 10.1016/j.ssci.2021.105431.

[4] International Labor Organization (ILO), "Safety and Health at Work," 2018. http://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.html (accessed Jun. 25, 2022).

[5] C. Akcay, S. Aslan, B. Sayin, and E. Manisalı, "Estimating OHS costs of building construction projects based on mathematical methods," Safety Science, vol. 109, pp. 361–367, Nov. 2018, doi: 10.1016/j.ssci.2018.06.021.

[6] N. Umeokafor, A. Windapo, and K. Evangelinos, "Causal inferences of external–contextual domains on complex construction, safety, health and environment regulation," Safety Science, vol. 118, pp. 379–388, Oct. 2019, doi: 10.1016/j.ssci.2019.05.033.

[7] C. Sohrabi et al., "World Health Organization declares global emergency: A review of the 2019 novel coronavirus (COVID-19)," International Journal of Surgery, vol. 76. Elsevier Ltd, pp. 71–76, Apr. 01, 2020. doi: 10.1016/j.ijsu.2020.02.034.

[8] C. Nnaji and A. A. Karakhan, "Technologies for safety and health management in construction: Current use, implementation benefits and limitations, and adoption barriers," Journal of Building Engineering, vol. 29, May 2020, doi: 10.1016/j.jobe.2020.101212.

[9] A. Pamidimukkala and S. Kermanshachi, "Impact of Covid-19 on field and office workforce in construction industry," Project Leadership and Society, vol. 2, p. 100018, Dec. 2021, doi: 10.1016/j.plas.2021.100018.

[10] A. Shibani, D. Hassan, and N. Shakir, "The Effects of Pandemic on Construction Industry in the UK," Mediterranean Journal of Social Sciences, vol. 11, no. 6, p. 48, Nov. 2020, doi: 10.36941/mjss-2020-0063.

[11] S. Rajendran, "Response to COVID 19 Challenges in Construction Sector - Experiences from USA," Safety and Health at Work, vol. 13, p. S41, 2022, doi: https://doi.org/10.1016/j.shaw.2021.12.847.

[12] A. Olanrewaju, A. AbdulAziz, C. N. Preece, and K. Shobowale, "Evaluation of measures to prevent the spread of COVID-19 on the construction sites," Cleaner Engineering and Technology, vol. 5, p. 100277, 2021, doi: https://doi.org/10.1016/j.clet.2021.100277.

[13] B. Briggs, C. J. Friedland, I. Nahmens, C. Berryman, and Y. Zhu, "Industrial construction safety policies and practices with cost impacts in a COVID-19 pandemic environment: A Louisiana DOW case study," Journal of Loss Prevention in the Process Industries, vol. 76, May 2022, doi: 10.1016/j.jlp.2021.104723.

[14] A. S. Almohassen, M. S. Alkhaldi, and M. E. Shaawat, "The effects of COVID-19 on safety practices in construction projects," Ain Shams Engineering Journal, p. 101834, May 2022, doi: 10.1016/j.asej.2022.101834.

[15] Y. M. Goh, J. Tian, and E. Y. T. Chian, "Management of safe distancing on construction sites during COVID-19: A smart real-time monitoring system," Computers and Industrial Engineering, vol. 163, Jan. 2022, doi: 10.1016/j.cie.2021.107847.

[16] F. Araya, "Modeling working shifts in construction projects using an agent-based approach to minimize the spread of COVID-19," Journal of Building Engineering, vol. 41, Sep. 2021, doi: 10.1016/j.jobe.2021.102413.

[17] Y. Gao, J. Meng, J. Shu, and Y. Liu, "BIM-based task and motion planning prototype for robotic assembly of COVID-19 hospitalisation light weight structures," Automation in Construction, vol. 140, p. 104370, Aug. 2022, doi: 10.1016/j.autcon.2022.104370.

[18] D. Michaels and G. R. Wagner, "Occupational Safety and Health Administration (OSHA) and Worker Safety during the COVID-19 Pandemic," JAMA - Journal of the American Medical Association, vol. 324, no. 14. American Medical Association, pp. 1389–1390, Oct. 13, 2020. doi: 10.1001/jama.2020.16343.

[19] L. Godderis and J. Luyten, "Challenges and opportunities for occupational health and safety after the COVID-19 lockdowns," Occupational and Environmental Medicine, vol. 77, no. 8. BMJ Publishing Group, pp. 511–512, Aug. 01, 2020. doi: 10.1136/oemed-2020-106645.

[20] S. Newnam and C. Muir, "Reforming the future of workplace road safety using systems-thinking workplace road safety surveillance," Safety Science, vol. 138, Jun. 2021, doi: 10.1016/j.ssci.2021.105225.

[21] M. Alkaissy, M. Arashpour, A. Rashidi, S. R. Mohandes, and P. Farnood, "Simulation-based analysis of occupational health and safety continuous improvement (OHSCI) in modern construction and infrastructure industries," Automation in Construction, vol. 134, p. 104058, 2022, doi: https://doi.org/10.1016/j.autcon.2021.104058.

[22] A. S. Rao et al., "Real-time monitoring of construction sites: Sensors, methods, and applications," Automation in Construction, vol. 136, p. 104099, 2022, doi: https://doi.org/10.1016/j.autcon.2021.104099.

[23] X. Li, D. Yang, J. Yuan, A. Donkers, and X. Liu, "BIM-enabled semantic web for automated safety checks in subway construction," Automation in Construction, vol. 141, p. 104454, 2022, doi: https://doi.org/10.1016/j.autcon.2022.104454.

[24] E. Stefana, F. Ustolin, and N. Paltrinieri, "IMPROSafety: A risk-based framework to integrate occupational and process safety," Journal of Loss Prevention in the Process Industries, vol. 75, Feb. 2022, doi: 10.1016/j.jlp.2021.104698.

[25] B. Daniotti, M. Gianinetto, S. Della, and T. Editors, "Research for Development Digital Transformation of the Design, Construction and Management Processes of the Built Environment." [Online]. Available: http://www.springer.com/series/13084

[26] Y. Lu, P. Gong, Y. Tang, S. Sun, and Q. Li, "BIM-integrated construction safety risk assessment at the design stage of building projects," Automation in Construction, vol. 124, Apr. 2021, doi: 10.1016/j.autcon.2021.103553.

[27] W. H. Collinge, K. Farghaly, M. H. Mosleh, P. Manu, C. M. Cheung, and C. A. Osorio-Sandoval, "BIM-based construction safety risk library," Automation in Construction, vol. 141, p. 104391, Sep. 2022, doi: 10.1016/j.autcon.2022.104391.

[28] M. Xu, X. Nie, H. Li, J. C. P. Cheng, and Z. Mei, "Smart construction sites: A promising approach to improving on-site HSE management performance," Journal of Building Engineering, vol. 49, p. 104007, 2022, doi: https://doi.org/10.1016/j.jobe.2022.104007.

[29] C. K. I. Che Ibrahim, P. Manu, S. Belayutham, A. M. Mahamadu, and M. F. Antwi-Afari, "Design for safety (DfS) practice in construction engineering and management research: A review of current trends and future directions," Journal of Building Engineering, vol. 52. Elsevier Ltd, Jul. 15, 2022. doi: 10.1016/j.jobe.2022.104352.

[30] F. Luo, R. Y. M. Li, M. J. C. Crabbe, and R. Pu, "Economic development and construction safety research: A bibliometrics approach," Safety Science, vol. 145, Jan. 2022, doi: 10.1016/j.ssci.2021.105519.

[31] J. K. Tamala, E. I. Maramag, K. A. Simeon, and J. J. Ignacio, "A bibliometric analysis of sustainable oil and gas production research using VOSviewer," Cleaner Engineering and Technology, vol. 7, Apr. 2022, doi: 10.1016/j.clet.2022.100437.

[32] J. Zhang et al., "A bibliometric and visual analysis of indoor occupation environmental health risks: Development, hotspots and trend directions," Journal of Cleaner Production, vol. 300. Elsevier Ltd, Jun. 01, 2021. doi: 10.1016/j.jclepro.2021.126824.

[33] I. Bautista-Bernal, C. Quintana-García, and M. Marchante-Lara, "Research trends in occupational health and social responsibility: A bibliometric analysis," Safety Science, vol. 137, May 2021, doi: 10.1016/j.ssci.2021.105167.

[34] Y. Yang, G. Chen, G. Reniers, and F. Goerlandt, "A bibliometric analysis of process safety research in China: Understanding safety research progress as a basis for making China's chemical industry more sustainable," Journal of Cleaner Production, vol. 263. Elsevier Ltd, Aug. 01, 2020. doi: 10.1016/j.jclepro.2020.121433.

[35] S. Kasavan, S. Yusoff, M. F. Rahmat Fakri, and R. Siron, "Plastic pollution in water ecosystems: A bibliometric analysis from 2000 to 2020," Journal of Cleaner Production, vol. 313, Sep. 2021, doi: 10.1016/j.jclepro.2021.127946.

[36] K. Sharun et al., "Mapping global trends in adipose-derived mesenchymal stem cell research: A bibliometric analysis using scopus database," Annals of Medicine and Surgery, vol. 77, May 2022, doi: 10.1016/j.amsu.2022.103542.

[37] M. Hu and D. Milner, "Visualizing the research of embodied energy and environmental impact research in the building and construction field: A bibliometric analysis," Developments in the Built Environment, vol. 3, Aug. 2020, doi: 10.1016/j.dibe.2020.100010.

[38] M. Su, H. Peng, and S. Li, "A visualized bibliometric analysis of mapping research trends of machine learning in engineering (MLE)," Expert Systems with Applications, vol. 186, Dec. 2021, doi: 10.1016/j.eswa.2021.115728.

[39] N. J. van Eck and L. Waltman, "Citation-based clustering of publications using CitNetExplorer and VOSviewer," Scientometrics, vol. 111, no. 2, pp. 1053–1070, May 2017, doi: 10.1007/s11192-017-2300-7.

[40] W. N. F. Wan Mustaffa, A. I. Che Ani, and A. H. Hussain, "Bibliometric Analysis of Post-Occupancy Evaluation (POE): Current Status, Development, and Future Research Directions," International Journal of Sustainable Construction Engineering and Technology, vol. 13, no. 1, May 2022, doi: 10.30880/ijscet.2022.13.01.010.

[41] D. Shkundalov and T. Vilutienė, "Bibliometric analysis of building information modeling, geographic information systems and web environment integration," Automation in Construction, vol. 128. Elsevier B.V., Aug. 01, 2021. doi: 10.1016/j.autcon.2021.103757.

[42] J. Yang and Z. Liu, "The effect of citation behaviour on knowledge diffusion and intellectual structure," Journal of Informetrics, vol. 16, no. 1, Feb. 2022, doi: 10.1016/j.joi.2021.101225.

[43] L. Wang, X. Tong, and Y. X. R. Wang, "Statistics in everyone's backyard: An impact study via citation network analysis," Patterns, p. 100532, Jun. 2022, doi: 10.1016/j.patter.2022.100532.

[44] V. K. Singh, P. Singh, M. Karmakar, J. Leta, and P. Mayr, "The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis," Scientometrics, vol. 126, no. 6, pp. 5113–5142, Jun. 2021, doi: 10.1007/s11192-021-03948-5.

[45] C. F. Oduoza, O. Odimabo, and A. Tamparapoulos, "Framework for Risk Management Software System for SMEs in the Engineering Construction Sector," Procedia Manufacturing, vol. 11, pp. 1231–1238, 2017, doi: 10.1016/j.promfg.2017.07.249.

[46] Y. Z. Toh, Y. M. Goh, and B. H. W. Guo, "Knowledge, Attitude, and Practice of Design for Safety: Multiple Stakeholders in the Singapore Construction Industry," Journal of Construction Engineering and Management, vol. 143, no. 5, p. 04016131, 2017, doi: 10.1061/(asce)co.1943-7862.0001279.

[47] M. Fargnoli and M. Lombardi, “Building Information Modelling (BIM) to Enhance Occupational Safety in Construction Activities: Research Trends Emerging from One Decade of Studies,” Buildings, vol. 10, no. 98, pp. 1–23, 2020, doi: 10.3390/BUILDINGS10060098.

[48] M. A. Hossain, E. L. S. Abbott, D. K. H. Chua, T. Q. Nguyen, and Y. M. Goh, “Design-for-Safety knowledge library for BIM-integrated safety risk reviews,” Automation in Construction, vol. 94, pp. 290–302, 2018, doi: 10.1016/j.autcon.2018.07.010.

[49] X. Xiahou, K. Li, F. Li, Z. Zhang, Q. Li, and Y. Gao, “Automatic Identification and Quantification of Safety Risks Embedded in Design Stage: a BIM-Enhanced Approach,” Journal of Civil Engineering and Management, vol. 28, no. 4, pp. 278–291, 2022, doi: 10.3846/jcem.2022.16560.

[50] K. Amponsah-Tawiah, “Occupational Health and Safety and Sustainable Development in Ghana,” International Journal of Business Administration, vol. 4, no. 2, pp. 74–78, 2013, doi: 10.5430/ijba.v4n2p74.

[51] K. Jilcha and D. Kitaw, “Industrial Occupational Safety and Health Innovation for Sustainable Development,” Engineering Science and Technology, an International Journal, vol. 20, no. 1, pp. 372–380, 2017, doi: 10.1016/j.jestch.2016.10.011.

[52] D. Kang, “Positive Factors for Return to Work After Accidents: Health Awareness, Consultation with Doctors, and Personal Characteristics of Workers,” Safety and Health at Work, vol. 13, no. 1, pp. 32–39, 2022, doi: 10.1016/j.shaw.2021.10.001.

[53] Y. Dai, X. Tong, and L. Wang, “Workplace Safety Accident, Employee Treatment, and Firm Value: Evidence from China,” Economic Modelling, vol. 115, p. 105960, 2022, doi: https://doi.org/10.1016/j.econmod.2022.105960.

[54] S. Kavouras, I. Vardopoulos, R. Mitoula, A. A. Zorpas, and P. Kaldis, “Occupational Health and Safety Scope Significance in Achieving Sustainability,” Sustainability (Switzerland), vol. 14, no. 4, pp. 1–17, 2022, doi: 10.3390/su14042424.

[55] F. Sierra, “COVID-19: main challenges during construction stage,” Engineering, Construction and Architectural Management, vol. 29, no. 4, pp. 1817–1834, Jan. 2022, doi: 10.1108/ECAM-09-2020-0719.

[56] D. Panahi, M. Sadeghi-Yarandi, N. Gharari, Z. A. Aliabadi, and A. Soltanzadeh, “Study of the Prevalence of COVID-19 Disease and Related Risk Factors in Two Groups of Industries with and without Occupational Health Management Systems,” 2021.

[57] A. Alsharef, S. Banerjee, S. M. J. Uddin, A. Albert, and E. Jaselskis, “Early impacts of the COVID-19 pandemic on the United States construction industry,” International Journal of Environmental Research and Public Health, vol. 18, no. 4, pp. 1–21, Feb. 2021, doi: 10.3390/ijerph18041559.

[58] J. Guzman, G. A. Recoco, A. W. Pandi, J. M. Padrones, and J. J. Ignacio, “Evaluating Workplace Safety in The Oil and Gas Industry During The COVID-19 Pandemic Using Occupational Health and Safety Vulnerability Measure and Partial Least Square Structural Equation Modelling,” Cleaner Engineering and Technology, vol. 6, p. 100378, 2022, doi: 10.1016/j.clet.2021.100378.

[59] G. K. Koulinas, O. E. Demesouka, P. K. Marhavilas, A. P. Vavatsikos, and D. E. Koulouriotis, “Risk Assessment Using Fuzzy TOPSIS and PRAT for Sustainable Engineering Projects,” Sustainability, vol. 11, no. 3, pp. 1–15, 2019, doi: 10.3390/su11030615.

[60] F. J. Cantero-Sánchez, J. M. León-Rubio, R. Vázquez-Morejón, and J. M. León-Pérez, “Evaluation of An Assertiveness Training Based on The Social Learning Theory for Occupational Health, Safety and Environment Practitioners,” Sustainability, vol. 13, no. 20, pp. 1–14, 2021, doi: 10.3390/su132011504.