



# Düzce University Journal of Science & Technology

Research Article

## Bibliometric Analysis of Occupational Health and Safety Research in the Construction Industry: Worldwide Trends and Key Focal Points (1990-2023)

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DOI: 10.29130/dubited.1340700

### ABSTRACT

In terms of accidents at work and work-related illnesses, the construction sector ranks among the top three. Occupational health and safety (OHS) research is therefore increasingly prevalent in this sector. However, there is a lack of bibliometric analysis carried out on these studies. The aim of this study is to examine, through bibliometric analysis, the research carried out worldwide on accidents in the construction sector and the key points emphasized in these studies. Bibliometrix, an R-based software, was used to analyze the articles included in this study. Accordingly, 48,046 studies were identified in a search of the SCOPUS database using the term "occupational health and safety". The results of this study indicate that the documents cover the time period from 1990 to 2023 and are spread across 187 different sources, including journals, books, book chapters, and conference papers. With an annual growth rate of 3.39%, the average age of documents is 8.27 years. The safety climate and training are key issues in the studies. When examining the data, it can be observed that the majority of publications come from Australia. Within their respective groups, Turkey, the United Kingdom, Malaysia, Italy, Singapore, South Africa, China, Greece, and Indonesia are closely related. Canada and Spain are connected through other groups. The fact that the most cited study comes from Turkey and is one of the top publications indicates the high priority given to OHS in recent years.

**Keywords:** Construction industry, bibliometric analysis, occupational health and safety, occupational accident

## İnşaat Sektöründe İş Sağlığı ve Güvenliği Araştırmalarının Bibliyometrik Analizi: Dünya Genelindeki Trendler ve Önemli Odak Noktaları (1990-2023)

### ÖZET

İnşaat sektörü, iş kazaları ve işle ilgili hastalıklar açısından en üst sıralarda yer alan üç sektör arasında yer almaktadır. Bu nedenle, bu sektörde iş sağlığı ve güvenliği (İSG) üzerine yapılan araştırmalar artmaktadır, ancak bu çalışmalar üzerinde yeterli bibliyometrik analiz yapılmamaktadır. Bu çalışma, inşaat sektöründeki kazalar üzerine dünya çapında yapılan araştırmaları ve bu çalışmalarda vurgulanan temel noktaları bibliyometrik analiz kullanarak incelemeyi amaçlamaktadır. Bu çalışmada dikkate

alınan makaleler, R tabanlı bir yazılım olan Bibliometrix kullanılarak analiz edildi. SCOPUS veri tabanında "İş sağlığı ve güvenliği" terimini kullanarak yapılan arama sonucunda 48.046 çalışma bulundu. Bu çalışmanın sonuçları, belgelerin 1990 ile 2023 yılları arasındaki dönemi kapsadığını ve dergiler, kitaplar, kitap bölümleri ve konferans bildirileri de dahil olmak üzere 187 farklı kaynaktan yayımlandığını göstermektedir. Belgelerin ortalama yaşı 8.27'dir ve yıllık büyüme oranı %3.39'dur. Çalışmalar, güvenlik iklimi ve eğitim konularına büyük önem vermektedir. Veriler incelendiğinde, yayınların çoğunun Avustralya'dan geldiği görülmektedir. İlgili gruplar içinde Türkiye, Birleşik Krallık, Malezya, İtalya, Singapur, Güney Afrika, Çin, Yunanistan ve Endonezya yakın ilişkilere sahiptir. Kanada ve İspanya, diğer gruplar aracılığıyla bağlantılıdır. En çok alıntı yapılan çalışmanın Türkiye'den olması ve en üstteki yayınlar arasında yer alması, son yıllarda İSG'ye verilen yüksek düzeyde önemi göstermektedir.

**Anahtar Kelimeler:** İnşaat sektörü, bibliyometrik analiz, iş sağlığı ve güvenliği, iş kazası

## **I. INTRODUCTION**

The construction sector has become an important industry worldwide, as housing is one of the basic human needs. In terms of meeting the needs of the labor market, it is also one of the most important sectors.

Germany is the country with the lowest number of accidents at work, while the United States has the highest number of accidents at work, according to the 2023 data from International Labor Organization (ILO). In the United States, agriculture, forestry and fishing stands out as the sector with the highest rate of accidents at work, at 57.4% in 2020-22, while construction is in fifth or sixth place [1]. Turkey is the country with the second highest number of workplace accidents after the United States. Of the accidents, in Turkey, the mining and quarrying sector has the highest accident rate (43.4 %), while the education sector has the lowest (0.1 %). Out of the economic sectors, the construction sector ranks at the third place in Turkey. Such a high importance might lead to the intensive work-load, which in turn brings about a high number of workplace accidents. This is supported by the data from ILO in 2023, which reported that 20 workers in Turkey and 16 workers in the United States were involved in accidents per 100,000 workers [2]. In the last nine years, 12,408 workers in Turkey have lost their lives as a result of work-related accidents. The construction sector alone accounted for around 35% of these fatalities, or 4,363 deaths [3].

The Social Security Institution identifies the construction, mining, and metal sectors as the leading industries in terms of combatting work accidents and occupational diseases [4]. To minimize the incidence of occupational accidents and diseases, governments have enacted laws and regulations with sanctions [5]. These sanctions require employers to provide certain regulations and training in the workplace and to provide their employees with the necessary protective equipment and materials [6]. In addition to the inspection systems they have established, all countries on our planet have common codes with the countries they have reached an agreement with, and these countries conduct their inspections in the field of OHS using these established systems. Achieving positive results at the inspection and investigation stages requires well-trained staff and systematic inspections [7]. For these reasons, health and safety issues are of great importance in the construction industry. In this regard, a large number of reports dealing with accidents in the construction industry and their possible causes have been published, as evidenced in finding section of the current work. As a common phenomenon idea of occupational health and safety, elimination of the potential risks must be the priority [8]. In this context, Sanchez et al. (2017) [9] underscored that construction workers are required to perform a wide range of tasks that involve some degree of risk. The workers are likely to be exposed to work-related accidents due to the nature of the work. Construction workers are the most vulnerable as they are exposed to potential risks and hazards throughout the construction process [10].

Workplace accidents and occupational diseases not only affect health and safety in the workplace, but also have an impact on the economy due to the high costs associated with workplace accidents. The cost

of construction site injuries can have a significant impact on the financial performance of construction companies, increasing overall construction costs by up to 15%. Investing in accident prevention is therefore not only important for health and safety management, but also for reducing the cost of construction projects [11].

As the importance of occupational safety and health has grown, the number of publications in this area has generally increased. This led to an overall improvement in the accumulation of knowledge in certain areas. Therefore, bibliometric studies have become increasingly important in recent years because, compared with traditional methods; they allow large numbers of reports to be classified more easily and interpreted more systematically [12]. Considering such a reductive approach, we have herein used Bibliometric methods in order to examine and analyzed the topics in construction related to OHS in terms of some key parameters such as time-trend, core content (keyword and term analysis), scientific productivity and spatial distribution. For the present study, we have used VOSviewer and R-Studio based Bibliometrix tools for the reduction of the dimension of the documents. Both of these tools are free online software. Nees Jan van Eck and Ludo Waltman [13] published the VOSviewer software. In addition, Bibliometrix in very powerful to obtain a complete bibliometric analysis in a science mapping. The program was developed by Massimo Aria and Corrado Cuccurullo [14]. After optimization of running conditions of the program and construction of BibTex file version of SCOPUS documents (Bibliometrix) and CSV file version of the SCOPUS documents (VOSviewer), the relevant documents are used for the analysis considered. Such great software tools have been recently applied in a wide range of fields [15-19]. The mechanisms of the both tools are based on mapping and network construction of the documents, researchers, journals, countries, keywords; terms etc. prior to analysis, some criteria by researchers are applied. For instance, a criterion as “minimum number of occurrences of a keyword”, “minimum number of occurrences of a term or “minimum number of documents released by countries” are of the commonly applied by the researchers. Subsequently, total strength of the co-occurrence links with others are calculated, as in the case of “term” and “keyword” analysis. As in the case of all disciplines, there is a high number of reputed review and original articles [20]. Those reports have contributed a lot in pioneering the researchers to new avenues. Significantly, the state of the art has been suggested for each topic. However, as a recent approach; such software-aided analyses are very recent, in comparison to the descriptive review articles. For that reason, we have directed our concern towards on the reduction of the documents available [21]. Along with the current analysis, we have focused our interest on author analysis to see which authors have produced more work in these areas, and on keyword and term analysis to identify the most prominent words. In addition, we have furthermore addressed the interest on the publication sources. Finally, for some specific countries, the country specific analysis was carried out. Concerning country analyses, international studies and inter-country collaboration network maps are also generated.

## **II. MATERIALS AND METHODS**

### **A. DATA SOURCE AND SEARCH STRATEGY**

The SCOPUS database was used to access the articles examined in this study. The main reason for choosing this database is that it provides advanced tools and analyses for conducting research, as well as a unique citation index, citation results and detailed researcher profiles [22]. The SCOPUS database includes 45,806 sources/journals, being one of the largest databases. It is one of the most reliable data-sources [17]. We conducted a search on SCOPUS using the keywords "occupational health and safety" for this analysis (TITLE-ABS-KEY ("Construction Industry" AND "Occupational Health and Safety") (Access date: 18 January 2023). Accordingly, the search yielded 48,046 studies. The search was then limited to the category of 'construction industry'. Finally, between 1990 and 2023, a-377 documents

have been recorded. The documents were analyzed with the two-different software, namely Bibliometrix and VOSviewer. The details/scope of the software were given in sub-sections.

## **B. ANALYZING DATA**

First, the documents of the interest (N=377) were downloaded in BibTex format, which was subsequently used in Bibliometrix program. Bibliometrix is a unique tool, developed in the R language that allows statistical calculations and graphs to be generated in accordance with logical bibliometric workflows. It is flexible and can be rapidly developed. It can be integrated with other R-based statistical programs. It is therefore a useful tool in constantly changing fields such as bibliometrics [23]. It is specifically used in the process of science mapping

## **C. VISUALIZATION OF DATA**

As in the case of analysis with Bibliometrix, we first exported the selected documents to the CSV format. The downloaded file was used in VOSviewer software. VOSviewer is used to construct and visualize bibliometric networks. These networks can include journals, researchers, or individual publications and can be created based on citation, bibliographic coupling, co-citation, or co-authorship relationships. This software tool also provides text mining functionality that can be used to create and visualize co-occurrence networks of important terms extracted from scientific literature (vosviewer.com). Using the VOSviewer software, keyword mining, citation analysis and bibliographic linkage analysis were performed on the 377 data sets [20].

# **III. RESULTS AND DISCUSSION**

Many studies on the construction sector and OHS can be found by searching the Scopus database. Table 1 summarizes the descriptive results of the 377 documents, indicating that the time range of the documents spans from 1990 to 2023. These articles are distributed across 187 different sources, including journals, books, book chapters, and conference papers. The estimated annual growth rate of these documents is 3.39%. Although some publications date back to before 1990, they are quite rare, so the starting year is considered as 1990, resulting in an average age of the documents being 8.27. The low average age of the reports is an indication that the reports are relatively recent and that there is a recent interest in the topic. In this context, the number of obtained sources is 184, and the number of studies is 377. These studies were written by a total of 962 authors, with 43 sources written by a single author. The international collaboration rate of these documents is 16.71%. The average number of collaborations per study is determined as 3.19. The average number of citations per study is 16.28. The total number of citations for these 377 documents is recorded as 13,730.

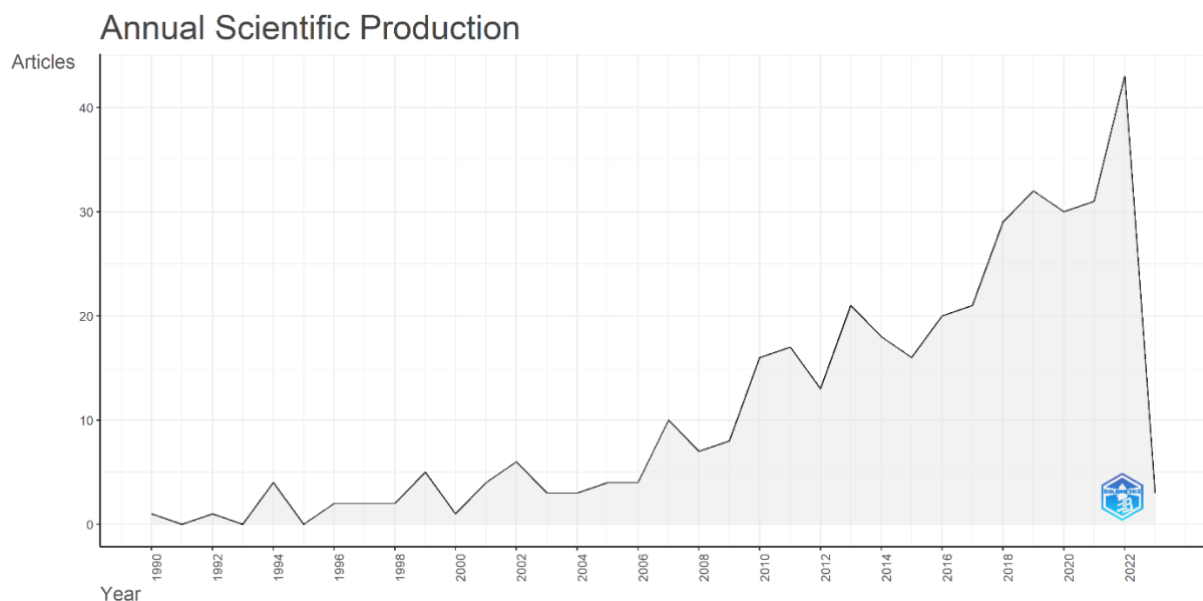
Considering the most cited documents, the document with highest number of citations (N=241) have been disseminated from Turkey. In this report, Aminbakhsh et al. [11] have underscored that construction projects are more susceptible to various risks arising from the nature of the work than other types of work. The study emphasized the importance of managers assessing and prioritizing risks and planning and budgeting for security risks. To realize this approach, the proposed framework presented a safety risk assessment framework based on safety cost theory and the analytical hierarchy process. The main purpose of risk assessment is the evaluation of risk elimination measures by means of cost-benefit analysis. This is because there may be more than one method of eliminating a risk and the most appropriate one for the organization should be selected. The proposed framework is intended to facilitate the collective decision-making process of the decision-makers and to minimize the bias in the decision-making process. As a result of the real-life study applied to a construction project, a hierarchy model has been created that improves the decision problem and weight assignment to criteria, and more

understandable sub-problems have been identified. Furthermore, a robust method for prioritizing safety risks using the AHP method is presented and the COS theory provides a procedure for setting realistic objectives and at the same time establishing a rational budget without compromising safety [11].

*Table 1. Summary Statistics and details of the retrieved documents*

Summary Statistics	Results
Time-span	1990-2023
Sources (journals, books, etc)	187
Documents	377
Annual growth rate	% 3,39
Document average age	8,27
Average citation per doc	16,28
References	13730
Author keywords	927
Authors	962
Authors of single-authored documents	43

Concerning the annual trend of publications (Figure 1), it can be seen that it remained stable between 1990 and 2006 and that it then increased rapidly after 2006. The rapid increase in the number of documents between 2006 and 2023 can be attributed to the increasing importance given to OHS in the construction sector, the high awareness of accidents and deaths, and the increasing compensation burdens for employers through legal regulations. It is clear that this is also in line with technological advances and the need for more housing as the population increases.

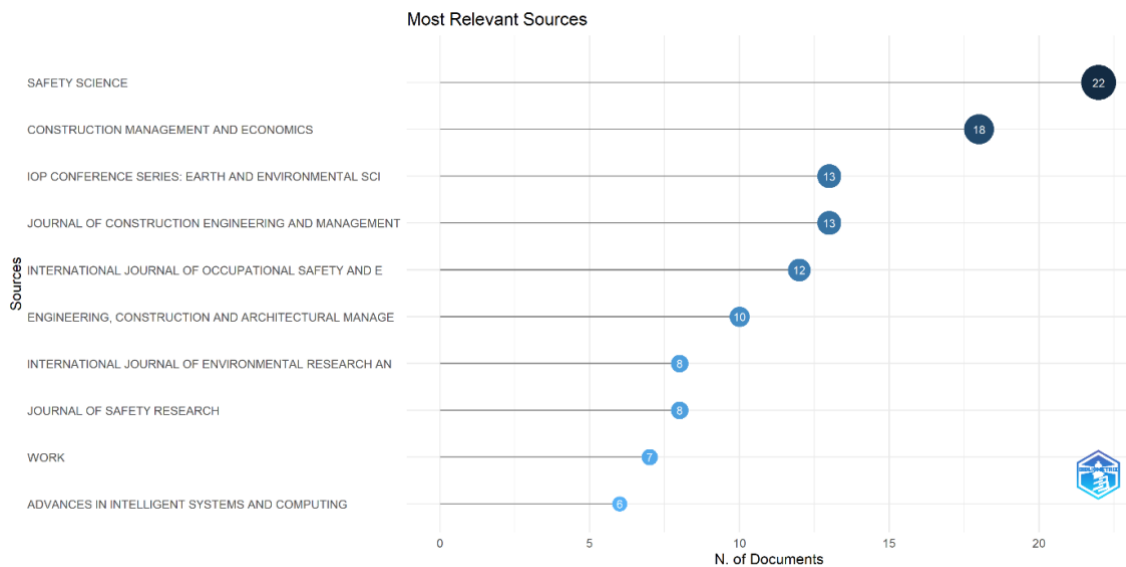


*Figure 1. Annual scientific production*

## A.MOST RELEVANT SOURCES

As shown in the previous section (Table 1), research on the investigation of construction accidents from an OSH perspective can be found in 187 different sources. These journals have been categorized based on their significance using the Bradford Law. As shown in Figure 2, 22 studies in the selected field were contributed by the source "Safety Science". It is followed by the source "Construction Management and Economics" with 18 studies. Among the other sources, "Journal of Construction and Engineering and

"Management" has 13 publications, "International Journal of Occupational Safety and Ergonomics" has 12 publications, and "Engineering, Construction and Architectural Management" has 10 publications.



*Figure 2. Most relevant sources*

## B. COUNTRY SCIENTIFIC PRODUCTIVITY

In Figure 3, the countries on the map are shown in different shades of blue and grey. The number of documents published by each country is indicated by the degree of color. Grey countries indicate no articles published on the topic according to the SCOPUS database. The documents might be found in non-SCOPUS indexed journals. On the other hand, the shades of blue represent a decreasing in the number of items as they move from darker to lighter shades. In other words, the countries that are colored in dark blue have a higher level of scientific productivity in this field. The countries colored in dark blue, from left to right on the map, are the United States, Spain, England, Turkey, South Africa, Australia, and with a slight difference in tone, Canada and China follow. The airline-like network seen between countries represents the intensity of their collaboration. This intensity is most prominently observed in Australia on the map. Occupational health and safety profession holds a significant place in Australia, and it is rare to find a medium to large-scale private or public organization without an Occupational Health and Safety (OHS) professional department [24]. Since 1990, there has been a substantial increase in university diploma programs related to OHS in the country [25]. As in the case of Australia, such regulation could explain the highest collaboration network, the lowest rate of workplace accidents or fatalities.

## Country Collaboration Map



**Figure 3.** Country collaboration map

Considering the construction sectors in countries considered for the present analysis, the activities of the relevant sector in Turkey has accelerated in 2022. Construction activity contracted at annual rates of 7.5%, 10.7% and 15% in the first three quarters of the year. Having continued to contract, the sector grew by 2% in the final quarter. Compared to the pandemic year 2020 (-5.5%), the sector experienced a stronger contraction in 2022 (-8.4%) [26].

The Australian construction sector is a significant part of the country's economy, generating \$168.8 billion in annual revenue and accounting for 9% of gross domestic product. Nationally, more than 1.1 million people are estimated to be employed in the construction sector [27]. The size of the Australian construction market is expected to achieve an average annual economic growth rate of over 3% from 2024 to 2027. The sector's growth during the forecast period will be supported by the government's continued focus on infrastructure development [28]. The industry has the highest rates of work-related injuries in sectors such as accommodation and food services (56.4 per 1000 workers), agriculture, forestry and fishing (53.6), transport, post and storage (50.8), public administration and security (49.4) and construction (49.3) [29]. Out of the 59 countries, 31 were included in the study by selecting documents with three or more documents (Figure 4.). Considering the scientific productivity (Figure 3), Australia has the highest number of publications. Within its own group, Turkey, United Kingdom, Malaysia, Italy, Singapore, South Africa, China, Greece and Indonesia are also related. Canada and Spain are also related to each other through other groups. America, Hong Kong, and UK are leading in their respective fields. It is noteworthy that Greece, Italy, and Canada have fewer citations and are located further away from the main center structure in the field of OHS in the construction sector in this map.

In the United States, construction costs declined due to lower prices for lumber, steel and aluminum. However, there is still upward pressure on prices for some materials, such as gypsum and concrete products. The overall increase in the cost of construction materials continues to outpace consumer price inflation. In 2023, growth in the non-residential sector almost offsets the sharp decline in single-family housing [30].

In the USA, there were 986 fatal injuries in the construction sector in 2021, of which 390 were due to causes such as falls, slips, and trips. The rate of fatal work accidents increased from 3.4 per 100,000 full-time equivalent workers in 2020 to 3.6 in 2021. Employers reported 2.6 million private sector injuries and illnesses in 2021, falling by 1.8% compared with 2020 [31]. In Canada, more than 40,000 workers are injured in fall accidents every year. Falls account for a significant percentage of the 'lost time injury' claims accepted by Workers Comp Boards in Canada [32]. In the United Kingdom, 135 workers were killed in accidents at work in 2022/23. The construction and agriculture, forestry and fishing sectors continue to be the sectors where the highest number of workers loses their lives in fatal

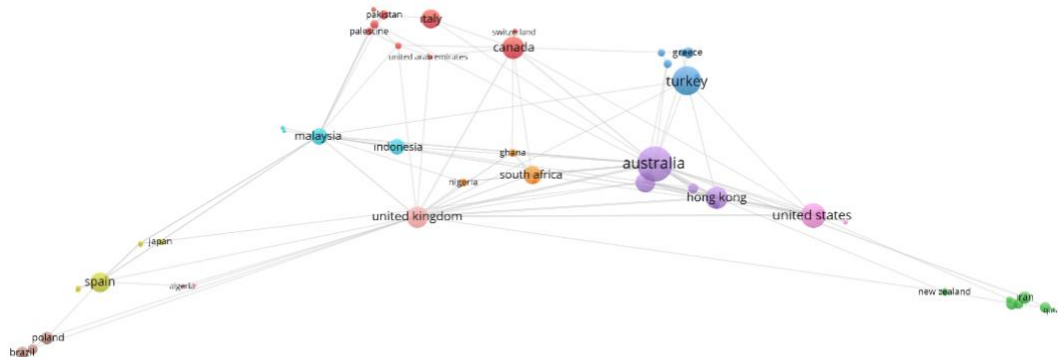
accidents every year [33]. This is due to legislation in the UK, which started much earlier than in other countries, so the figure is quite low.

The construction sector in China has been under increasing pressure from the challenges posed by China's zero COVID policy and policies to reduce developer leverage and further promote sustainability. Such pressures were manifested as a 2% reduction in construction growth. Investment in infrastructure and affordable housing accounts for around 3% of construction activity in 2022 [34]. With regard to the accident rate in the countries under analysis here, the relevant data entry was in 2022, as in the case of Turkey. Corresponding the indicators of OHS in ILOSTAT-Turkey data, the rate of non-fatal accidents at work per 100,000 persons in employment is 3549, whilst there are 20 fatal accidents at work per 100,000 employees [3]. As in the case of Australia, the last data entry was in 2022, reporting that the non-fatal occupational accident rate per 100,000 employees is 899 people; the fatal occupational accident rate per 100,000 employees is 1.6 people. As for China-Hong Kong, the last data entry was in 2016, indicating that the non-fatal occupational accident rate per 100,000 employees is 1,188.1 people; the fatal occupational accident rate per 100,000 employees is 6.8 people and in Hong Kong accident rates are approximately 68.1 per 1,000 workers, which is generally much higher than most neighboring countries, such as Singapore, where it is only about 9.4 per 100,000 workers [35]. Considering the ILOSTAT-USA data, the non-fatal occupational accident rate per 100,000 employees is 900 people (given as the total number including occupational diseases such as “Absenteeism in the Workplace, Asthma (work related, cancer etc.); the fatal occupational accident rate per 100,000 employees is 5.2 people [36]. There are several important reasons for the high accident rate in Hong Kong. High-rise buildings continue to dominate the city, presenting many hazards associated with working at height and vertical transport, such as falling objects or people [37].

On the other hand, when the countries with the highest levels of publishing are examined, it is clear that Australia and the United States impose heavy fines for non-compliance with OHS regulations and that these fines can bring about difficulties for employers who fail to comply. It is clear that Australia and the United States impose heavy fines. Failure to comply with these fines can cause problems for employers [38]. It can therefore be said that employers in these countries are obliged to comply with the requirements of the regulations because of the serious consequences of sanctions.

If we handle the fines imposed in Australia, we can see that they are in fact significantly higher than the fines imposed in the United States [39]. Compared to Australia, the amount of the fine in the United States seems quite low. As far as China is concerned, no information has been obtained on the specific amount of fines related to occupational safety and health laws/regulations. Therefore, no comment or comparison can be made for China.



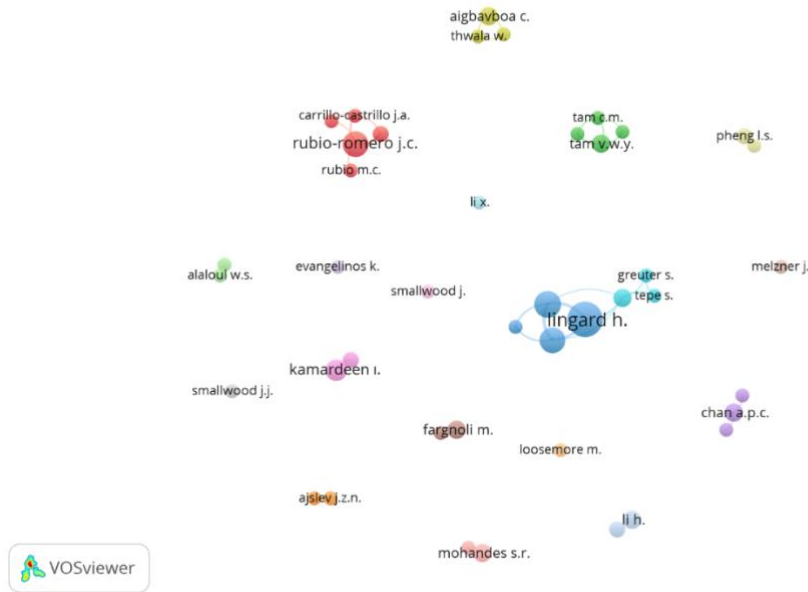


**Figure 4. Country Analysis.**

For construction of author analysis networks, the minimum number of documents of a country was set as  $N=3$ . No citation number criterion was applied for the analysis considered. Of the 59 countries contributing to the field, 31 authors met the threshold of  $N=3$ .

### C.AUTHOR ANALYSIS

Considering the network (s) of the authors included in the documents retrieved, a graphical structure in which authors create reciprocal citations was composed. Mutual citation networks are created by analyzing when two documents appear together in other documents. The more often these documents appear together in other documents, the larger and closer the nodes in the reciprocal citation network become [20]. It can be seen that the clustering of the authors is shown in different colors (Figure 5). Out of the authors, Lingard H. (Helen Lingard, Professor Emeritus, RMIT University) has the highest number of publications. It is also understood that she is in collaboration with Greuter S. and Tepe S., means that they have been working together.



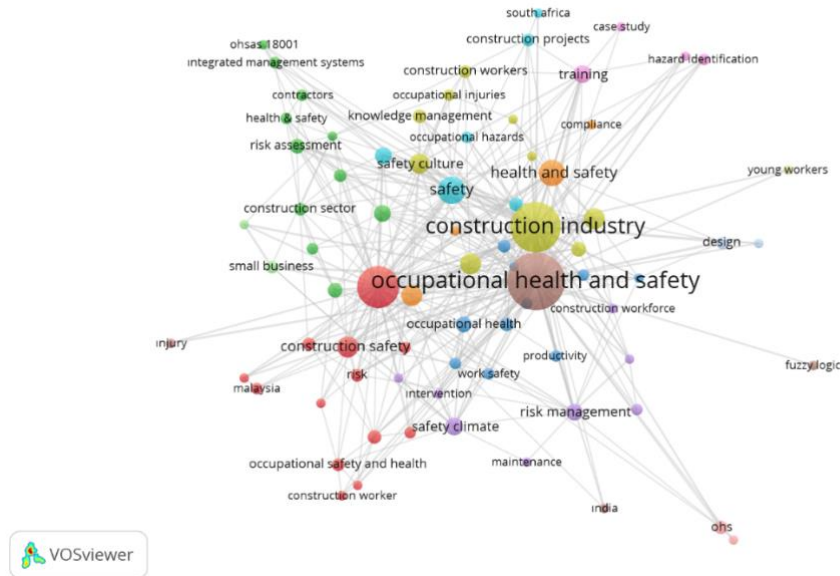
**Figure 5.** Author Analysis.

For construction of author analysis networks, the minimum number of documents of an author was set as N=3. No citation number criterion was applied for the analysis considered. Of the 918 authors contributing to the field, 42 authors met the threshold of N=3.

The issue of health and safety in construction is quite complex, and the most important advance needed to improve health and safety in construction is the need for multiple approaches to solving it [40]. Effective implementation of OHS in the workplace to minimize accidents and occupational diseases is possible through ongoing training programs (Figure 11.). Such initiatives are awareness-raisers in themselves. It is particularly important to involve learners and workers in construction education through games developed to identify hazards from the design stage onwards and manage them through OHS control measures [41].

#### **D .KEYWORD ANALYSIS**

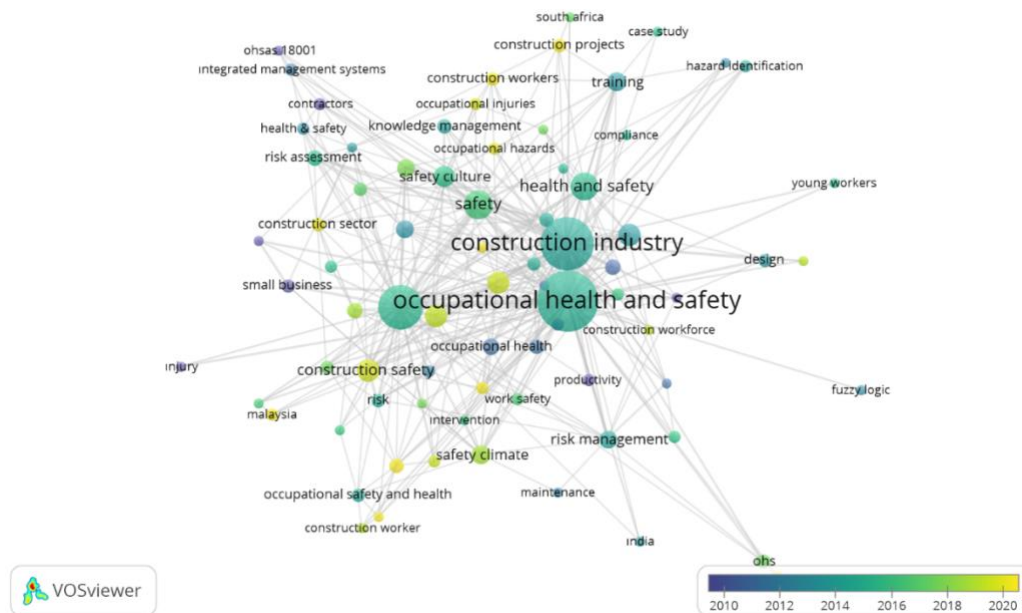
The VOSviewer map shows that the terms are mostly clustered under two main headings: 'health and safety' and 'building' (Figure 6). The words under these headings are also grouped together with each other. Construction safety, safety, risk management and safety culture are other items where the density of terms is visible. The cluster with the highest density is 'Occupational health and safety'. It is clear that the climate of security and the issue of education are of particular importance and should be the focus of attention.



**Figure 6. Keyword Analysis:**

For construction of keyword analysis networks, the minimum number of occurrences of a keyword was set as  $N=3$ . Of the 932 keywords used in the reports extracted, 77 keywords meet the threshold of  $N=3$ .

An indication of the level of interest over the years is the uses of keywords in the articles. To illustrate these trends, a 'keyword trends' analysis was carried out using VOSviewer (Figure 7). From this analysis, we can see that new keywords (highlighted in yellow) are emerging towards 2020 from articles published between 2010 and 2020. These new keywords have formed new clusters within the existing clusters of keywords that have been in use since 2010, and new relationships have been established.

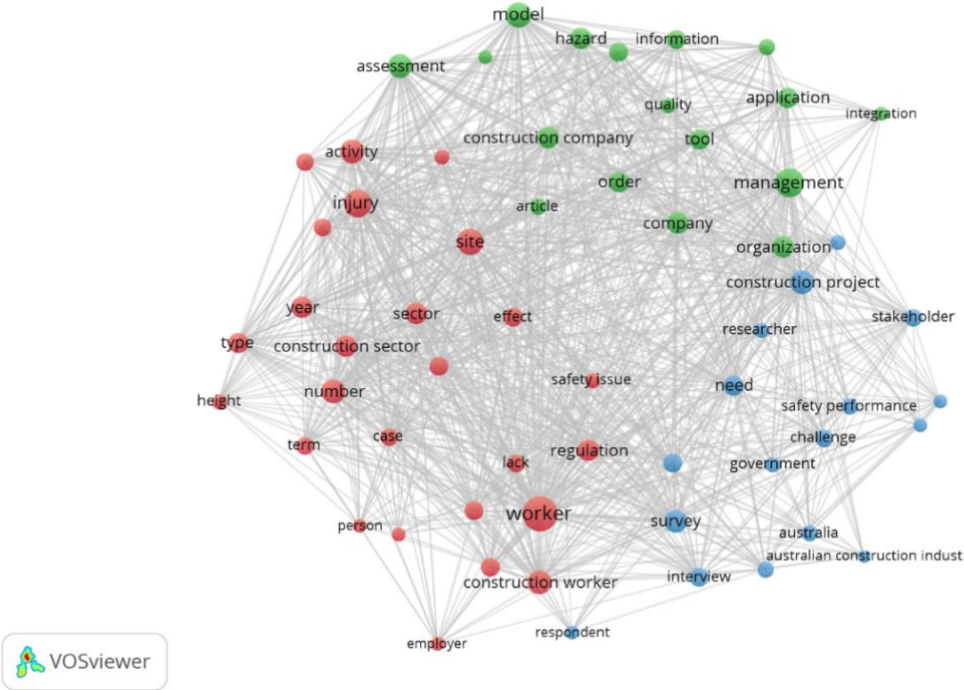


**Figure 7. Keyword Trends**

## E. TERM ANALYSIS

Out of the documents considered for the analysis, 8,562 terms were recorded. However, following a criterion including the minimum occurrence of a term as 20, we have noted only 100 terms, which were then used for subsequent visualization analysis. For each of these terms, a relationship score was then

calculated. On the basis of this score, the most relevant terms have been selected. Sixty percent of the most relevant terms were selected by default, resulting a-60 term for the study. The network can be classified into three clusters, which can be considered as project management, manual workers and construction activities (Figure 8). Each group is clearly distinguished from the other by a different color, indicating how they are related within the group.



**Figure 8. Term Analysis**

For construction of term analysis networks, the minimum number of occurrences of a term was set as N=20. Of the 8562 terms used in the reports extracted, 100 terms meet the threshold of N=20. Subsequently, for each of the 100 terms, a relevance score was calculated. Corresponding to the score, the most relevant terms were selected by the program. The default choice was to select the 60% most relevant terms. The number of terms shown in the network was 60.

In Figure 9, a map of the conceptual structure of the articles has been provided. This map is a representation of the proximity of words which are semantically related. The first cluster (red color) consists of 26 key words, including work accidents, risk assessment, construction companies, construction workers, construction sector, accidents, personnel training, Australia, safety management, occupational diseases, and procedures, which contains the most important group of articles related to them. Cluster 2 (in blue) is a group of 5 keywords with a focus on women, men, adults, middle-aged people and survey documents.

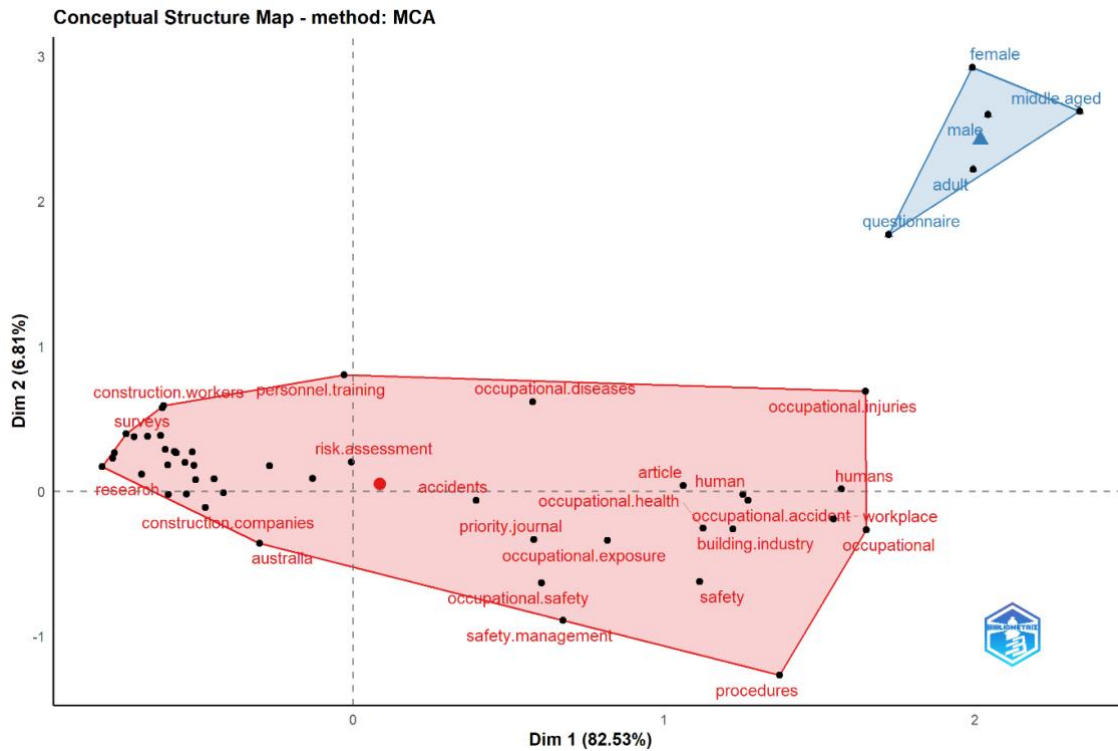


Figure 9. Conceptual structure map

### F. AREA BASED TREE ANALYSIS

Three area plots have been used for the evaluation of the author tree analysis. The three area graphs show the relationships between the selected areas. In the figure below (Figure 10), the names of the authors, the key words and the countries of authorship have been chosen as the three areas.

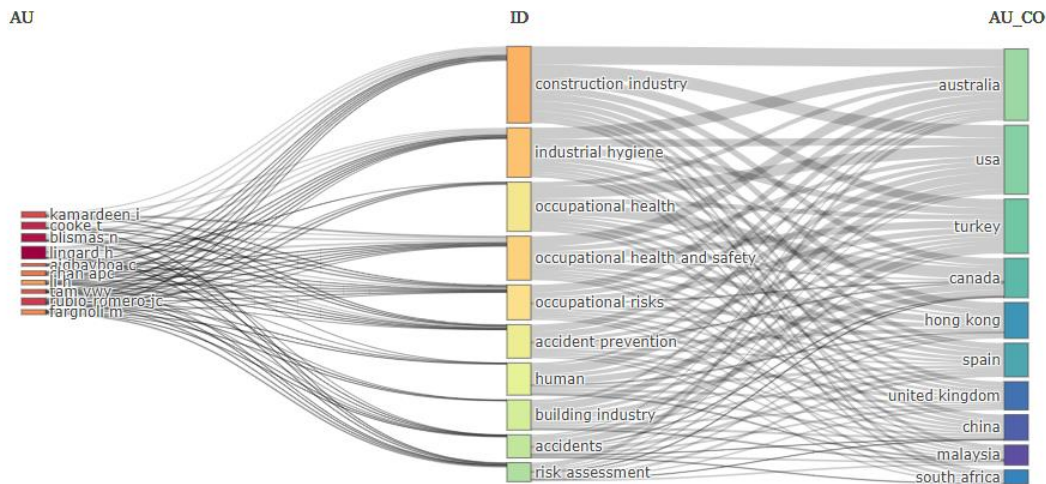


Figure 10. Tree-field plot

Concerning the three area charts (Figure 10), it can be seen that, on the left-hand side, authors use the keywords provided in the middle section to indicate which country they belong to or which country/countries they collaborate with to produce their work. The figure shows that almost all authors use the same common keywords. The most frequently used keyword is "construction industry". There is also a great diversity in the distribution of the countries to which the authors who use this keyword belong. The second most common keywords are 'industrial hygiene' and 'occupational health'. There is also a great deal of diversity in the distribution of the authors and the countries for these key words. In

the study, each author seems to have used all the common key words related to occupational safety and health. The least used keyword, according to the networks, is "risk assessment".

## G. WORD CLOUD ANALYSIS

In order to reveal the most frequently used common keywords in the documents considered for the analysis, we have constructed a word cloud using R-studio based Bibliometric. Accordingly, we have noted that “Building industry," "accidents," "risk assessment," "human" as the most frequently used words, being followed by the words 'industrial injury', 'health and safety' and 'occupational safety'. Taken together, the words in the word cloud; we can deduce that “risk assessment studies conducted with a focus on occupational health and safety play a critical role in ensuring the safety of human (employee), preventing them from workplace accidents during the all processes of the building (construction) industry”.



Figure 11. Word Cloud of keywords

## IV. CONCLUSION AND FUTURE DIRECTIONS

The construction industry requires a critical and solid approach to occupational health and safety because of the increase in accidents at work and work-related illnesses. In the present work, we have used two software tools to reveal the core and thematic content of the documents in the construction sector - OHS. In this respect, we have used the SCOPUS database for the retrieval of the documents. Accordingly, we have 377 documents from the years 1990 to 2023 on record. Considering how the documents evolve by the time, the relevant documents peaked after 2006. Regarding spatial distribution of the documents, Australia ranked the first for its documents and it was followed by USA and the UK. Along with the present study, we further constructed a word-cloud from the main text of the present study (Figure 12), aiming/revealing whether the thematic content of this study is consistent with the documents retrieved and considered for analysis. As expected, “construction” and “OHS” terms are more pronounced. Interestingly, the “country” term was also highlighted. The higher frequency of term “country” can be explained with country and its regulations for OHS. As we noted above, the legislations with respect to the OHS are of the critical factors in order to diminish the potential accidents at work, as in the case of the UK we have discussed above. In this respect, we can deduce that the thematic content of the current reports is very compatible with the main approach of OHS and linked documents.

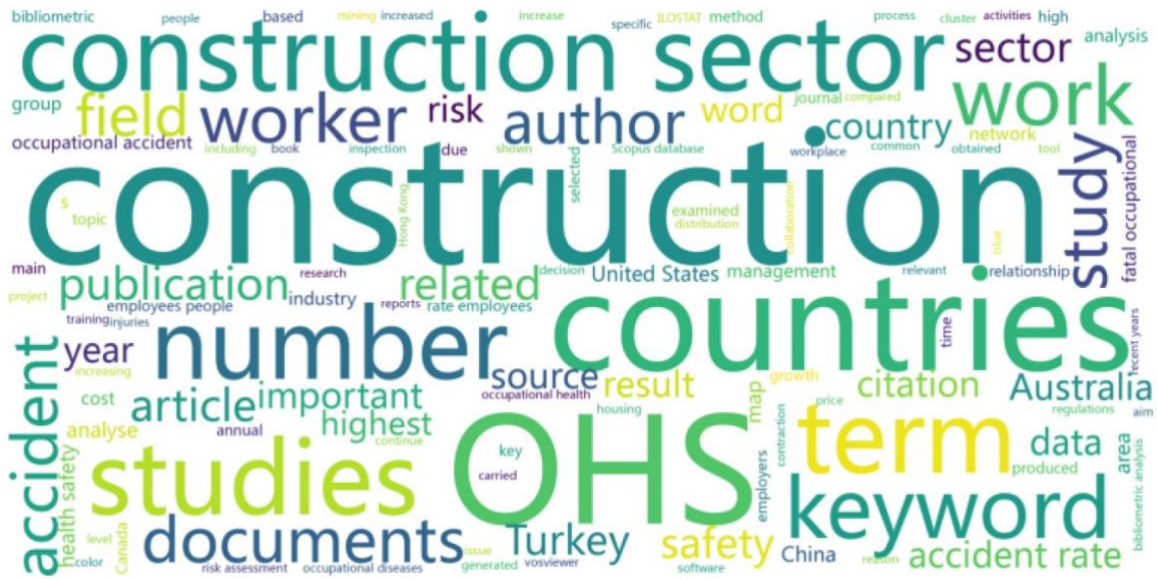


Figure 12. Word-cloud generated from the main text of the present study

Overall, these reviews have shown that the study of accidents in the construction sector from an OHS point of view is a subject that develops and can be researched every year. In addition, an examination of the authors and areas of interest of the articles shows that this field also interacts with engineering and management. As a result, this bibliometric analysis study has enabled us to obtain important information about the examination of accidents in the construction sector in terms of OHS and has provided a holistic perspective on the topic orientations and development of the field. For the countries with high rate of accidents, the future reports could address the i) implementation of OHS management systems, as in the case Australia, ii) training and education, iii) adherence to the international standards, and iv) development of a preventative safety and health culture. Following the introduction of such systems and training, accident rates could be monitored over a number of years to see how effective they are or are not.

**ACKNOWLEDGEMENTS:** This study is derived from the master's thesis of Elif Derya Yamaner KUZAYLI

## **V. REFERENCES**

- [1] US. Bureau of Labor Statistics. <https://www.bls.gov/news.release/osh.t02.htm>
- [2] Öztürk, T. ILO Üyesi Ülkelerin İş Kazası Sonucu Oluşan Ölüm Oranı Bakımından Kümeleme Yöntemi ile Sınıflandırılması. *SGD-Sosyal Güvenlik Dergisi*, vol:12, no:1, pp. 35-52, 2022.
- [3] Sosyal Güvenlik Kurumu, <https://www.sgk.gov.tr/Istatistik/Yillik/fcd5e59b-6af9-4d90-a451-ee7500eb1cb4>
- [4] Ö. Dinkçi ve T. Akpınar, “İş Sağlığı ve Güvenliği Bağlamında Türkiye’de İş Teftişinin Değerlendirilmesi (2012-2020),” *Balkan & Near Eastern Journal of Social Sciences (BNEJSS)*, vol. 9, no.3, 2023.
- [5] Y. Caraballo-Arias, “Occupational safety and health in Venezuela,” *Annals of global health*, vol. 81, no.4, pp. 512-521, 2015.

- [6] H. Durdu, "İş kazalarının ekonomik analizi ve bazı sektörler bazında değerlendirilmesi," *Sosyal Güvence*, vol.5, 2014.
- [7] S. Yılmaz "İşletmelerde kurumsallaşma ve iş kazaları arasındaki ilişkide iş güvenliği kültürünün aracılık rolü," Yüksek lisans, Sosyal Bilimler Enstitüsü, Hacıbektaş Veli Uni., Nevşehir, Türkiye, 2023.
- [8] R. M. Morillas, J. C. Rubio-Romero and A. Fuertes, "A comparative analysis of occupational health and safety risk prevention practices in Sweden and Spain," *Journal of safety research*, vol.47, pp. 57-65, 2013.
- [9] F. A. S. Sanchez, G. I. C. Pelaez and J. C. Alis, "Occupational safety and health in construction: a review of applications and trends," *Industrial health*, vol.55, no.3, pp. 210-218, 2017.
- [10] M. N. Nawi, S. H. Ibrahim, R. Affandi, N. A. Rosli ve Basri, M. N. "Factor Effecting Safety Performance Construction Industry," *International Review of Management and Marketing*, vol.6, no.8, pp. 280-285, 2016.
- [11] S. Aminbakhsh, M. Gunduz ve R. Sonmez, "Safety Risk Assessment Using Analytic Hierarchy Process (AHP) During Planning and Budgeting of Construction Projects," *Journal of Safety Research*, vol. 46, pp. 99-105, 2013.
- [12] E. Atabay, B. Çizel ve E. Ajanovic, "Akıllı Şehir Araştırmalarının R Programı ile Bibliometrik Analizi," 20. Ulusal Turizm Kongresi 2019, pp. 1130-1137, 2019.
- [13] N. J. Van Eck and L. Waltman, "Visualizing bibliometric networks. In *Measuring scholarly impact: Methods and practice*," Cham: Springer International Publishing, pp. 285-320, 2014.
- [14] M. Aria and C. Cuccurullo, "Bibliometrix: An R-tool for comprehensive science mapping analysis," *Journal of Informetrics*, vol.11, no.4, pp. 959-975, 2017.
- [15] A. Rejeb, A. Abdollahi, K. Rejeb and H. Treiblmaier, "Drones in agriculture: A review and bibliometric analysis," *Computers and electronics in agriculture*, vol. 198, pp. 107-117, 2022.
- [16] N. Niknejad, W. Ismail, M. Bahari, R. Hendradi and A. Z. Salleh, "Mapping the research trends on blockchain technology in food and agriculture industry: A bibliometric analysis," *Environmental Technology & Innovation*, vol.21, pp. 101-272, 2021.
- [17] Q. Chen, N. Geng and K. Zhu, "Review and bibliometric analysis of Chinese agricultural economics research: 2006-2015," *China Agricultural Economic Review*, vol. 10, no. 1, pp.152-172, 2018.
- [18] M. Kulak, A. Ozkan, ve R. Bindak, "A bibliometric analysis of the essential oil-bearing plants exposed to the water stress: How long way we have come and how much further?," *Scientia horticulturae*, vol. 246, pp. 418-436, 2019.
- [19] M. Kulak ve C. Gulmez Samsa, "Flavonoids Mediated Nanomaterials Synthesis, Characterization, and Their Applications," In *Secondary Metabolites Based Green Synthesis of Nanomaterials and Their Applications*, pp. 49-65, 2023.
- [20] M. Kulak ve N. Kilic, "A bibliometric analysis: How important is salicylic in response to the salinity from NaCl?," In *EGU General Assembly Conference Abstracts*, p. 1302, 2020.
- [21] N. J. Eck ve L. Waltman, "Software Survey: VOSviewer a Computer Program for Bibliometric Mapping," *Scientometrics*, vol. 84, pp. 523-538, 2009.



- [22] B. D. Deniz, "A Bibliometric Analysis of Critical Construction Management Studies," Yüksek Lisans Tezi, Mimarlık Bölümü, İzmir Yüksek Teknoloji Enstitüsü, İzmir, Türkiye, 2019.
- [23] R. E. Erdoğan, "Mimarlıkta Sayısal Tasarım Araştırmalarının Bibliometrik Yöntemlerle Analizi ve Haritalanması," Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, Başkent Üniversitesi, Ankara, Türkiye, 2020.
- [24] D. J. Provan and P. Pryor, "The emergence of the occupational health and safety profession in Australia," *Safety science*, vol. 117, pp. 428-436, 2019.
- [25] W. Macdonald, T. Driscoll, R. Stuckey and J. Oakman, "Occupational health and safety in Australia," *Industrial health*, vol. 50, no.3, pp. 172-179, 2012.
- [26] T. D. Baskan, A. Akpınar ve E. Baran, "Covid-19 Sürecinde İnşaat Sektöründeki İşletmelerin Finansal Durum Analizi," *Muhasebe Bilim Dünyası Dergisi*, vol. 24(Covid-19 Özel Sayısı), pp. 128-149, 2022.
- [27] D. Rivas-Aybar, M. John and W. Biswas, "Can the Hemp Industry Improve the Sustainability Performance of the Australian Construction Sector?," *Buildings*, vol. 13, no. 6, pp. 1504, 2023.
- [28] S. Petrovic-Lazarevic, "The development of corporate social responsibility in the Australian construction industry," *Construction management and Economics*, vol. 26, no. 2, pp. 93-101, 2008.
- [29] M. Alkaissy, M. Arashpour, E. M. Golafshani, M. R. Hosseini, S. Khanmohammadi, Y. Bai and H. Feng, "Enhancing construction safety: Machine learning-based classification of injury types," *Safety science*, vol. 162, pp. 106-120, 2023.
- [30] D. Arditi and K. Mochtar, "Trends in productivity improvement in the US construction industry," *Construction Management & Economics*, vol. 18 no. 1, pp. 15-27, 2000.
- [31] A. K. Ramos, S. Adhikari, A. M. Yoder and R. H. Rautiainen, "Occupational injuries among Latino/a immigrant cattle feedyard workers in the Central States Region of the United States," *International journal of environmental research and public health*, vol. 18, no. 16, pp. 8821, 2021.
- [32] N. Carnide, V. Nadalin, C. Mustard, C. N. Severin, A. D. Furlan and P. M. Smith, "Cannabis use among workers with work-related injuries and illnesses: results from a cross-sectional study of workers' compensation claimants in Ontario," *Canada. BMJ open*, vol. 13, no. 7, pp.1-11, 2023.
- [33] Health and Safety Executive, (2023, June), Work related ill health and injury statistics, (Online) <https://www.hse.gov.uk>
- [34] S. X. Zeng, V. W. Tam and C. M. Tam, "Towards occupational health and safety systems in the construction industry of China," *Safety science*, vol. 46, no. 8, pp. 1155-1168, 2008.
- [35] Fung, I. W., Tam, V. W., Lo, T. Y., & Lu, L. L. (2010). Developing a risk assessment model for construction safety. *International Journal of Project Management*, 28(6), 593-600.
- [36] ILO.ORG, (2023, April), Fatal Occupational Injuries per 100.000 Workers by Economic Activity, Annual, [https://www.ilo.org/shinyapps/bulkexplorer44/?lang=en&id=INJ\\_FATAL\\_ECO\\_RT\\_A](https://www.ilo.org/shinyapps/bulkexplorer44/?lang=en&id=INJ_FATAL_ECO_RT_A)
- [37] C. K. Hon, A. P. Chan and M. C. "Yam, Determining safety climate factors in the repair, maintenance, minor alteration, and addition sector of Hong Kong," *Journal of construction engineering and management*, vol. 139, no. 5, pp. 519-528, 2013.

[38] T. J. Kniesner and J. D. Leeth, "Workplace Safety Policy: Past, Present, and Future. *Present, and Future,*" 2000.

[39] T. John, "Workplace death and serious injury: a snapshot of legislative developments in Australia and overseas," Parliamentary Library, no.7, 2004.

[40] H. Lingard, "The effect of first aid training on Australian construction workers' occupational health and safety motivation and risk control behavior," *Journal of safety research*, vol. 33, no. 2, pp. 209-230, 2002.

[41] S. Greuter, S. Tepe, J. F. Peterson, F. Boukamp, K. Amazing, K. Quigley,... and R. Wakefield, "Designing a game for occupational health and safety in the construction industry," In *Proceedings of The 8th Australasian Conference on Interactive Entertainment: Playing the System*, pp. 1-8, 2012.