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A Bibliometric Analysis on Occupational Health and Safety in Constructions between 1996-2020

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Abstract
Numerous accidents in construction and the consequences of these accidents have made the care that the stakeholders of the building sector should show to human resources in terms of occupational health and safety. For this reason, the number of academic studies on occupational health and safety problems in the building sector is increasing. In this study, it was aimed to determine which subjects focused on academic studies produced to encourage a positive safety culture and improve safety performance of the construction site and to determine the areas and methods that should be studied in the future. For this purpose, within the scope of this study, the articles between 1996-2020, which were scanned within the scope of Analysis unit WoS using scientific mapping method, were examined. While the evolution map of the articles scanned with the keywords "Construction, Construction Workers, Risk, Occupational Health and Safety" were obtained, network and density charts were created with VOSviewer software and the trends of these studies were determined. In addition, potential study areas for future studies have been identified and proposed.
Keywods: Construction, Construction Workers, Occupational Health and Safety, Bibliyometric Analysis, Science Mapping Method, VOSviewer.

1. INTRODUCTION

According to the definition of the International Labor Organization (ILO), an occupational accident is "An unexpected and unplanned event that causes a certain damage or injury" (ILO, 2015), and according to the Occupational Health and Safety Law No. 6331 in force in our country; It is "an event that occurs in the workplace or due to the conduct of the work, causing death or rendering bodily integrity mentally or physically disabled" (Occupational Health and Safety Law, 2012).

An occupational accident occurs with the completion of the accident chain (other name is Domino Theory) consisting of Human Weakness Against Nature or Social Evolution, Personal Disabilities, Dangerous Situations and Behaviors, Accident Event, Injury, Damage or Damage (Mushori et al., 2021). The work accident that occurs as a result of these dangerous situations and actions is formulated as "Work Accident = Dangerous Situation X Dangerous Action". If one of the two risks is 0 (zero), the probability of an accident becomes 0 (zero). If you are very careful in an environment where a dangerous situation is known and no risky behavior is taken or all kinds of technical precautions are taken against dangerous behavior, the probability of accident will be zero. However, these assumptions are only mathematically correct and are not valid in practice. Since there are many factors affecting human behavior, it is not a realistic approach to assume that he will act flawlessly and work flawlessly, and it would be a more accurate study to reduce the risk of accident to zero by taking precautions according to both the dangerous situation and the dangerous action.

Occupational diseases can be completely prevented and occupational accidents can be prevented up to 98% by taking precautions and complying with the essence of the industry and the work done (Demir & Öz, 2018). However, as a result of negligence in taking precautions or complying with the measures taken, occupational accidents that result in injury, death and material damage every year in the world have become a global

problem due to their visible and invisible costs. Topics such as occupational accidents, their causes, prevention, the establishment of a safety culture, etc., which the world is closely interested in and focused on, have been the subject of scientific studies and researches.

Both researchers academic studies conducted by and both occupational health and safety professional studies conducted in the field (in a broad sense control and supervision mechanism be created, assessment of risks, elimination of non-conformities detected, repeating the training in accordance with certain intervals and hazard class) to improve the working environment and stakeholders work to raise awareness of health and safety. It is possible to adapt the methods developed by taking advantage of the opportunities brought by technology to occupational health and safety issues, by conducting the studies simultaneously in the academic environment and in the field.

Although the frequency and rate of occupational accidents vary on the basis of countries, depending on the cultural level, economic power and level of development of the society, it is a global problem in general (Buniya et al., 2021). The risk of fatal occupational injury in developing countries is almost 2 times higher than in developed countries, and there is a statistically significant inverse relationship between the human development index and the number of deaths due to occupational accidents (Baradan et al., 2019; Karadeniz, 2012). It is known that occupational accidents occur more in mining, construction, metal and transportation sectors than in other sectors (Unsar & Sut, 2009). According to ILO data, although the construction sector employs 6% to 10% of the workforce in industrialized countries, it is estimated to account for 25% to 40% of work-related deaths (Somavia, 2005). Despite all the improvement efforts, the number of occupational accidents occurring in the construction sector remains at the top of the world.

From this point on, in this study; By examining the sample of 162 articles prepared in the focus of occupational safety and published in journals scanned in the "web of science" database between 1996-2020, the current status of the occupational health and safety literature in the academic environment and the study gaps in the construction sector, which is one of the areas with the most occupational accidents, in the future It is aimed to contribute to the development of studies.

2. OCCUPATIONAL HEALTH AND SAFETY IN THE WORLD

In the Universal Declaration of Human Rights, it is stated that "Everyone has the right to work under fair and favorable working conditions at the workplace they freely choose" ("Universal Declaration of Human Rights (Chuukese)," 2007). The World Health Organization defines health as "health is not merely the absence of disease or infirmity, but a state of complete physical, social and mental well-being" ("World Health Organization," 1954). In this context, the purpose of occupational health and safety studies; To provide a safe and healthy working environment by protecting the employees from the dangers that threaten the right to life, which is the most basic right of the human being, and which often appear as accidents and occupational diseases, to protect the employees against health and safety risks, to ensure the continuity of production.

Worker health; The main objectives are to ensure the physical, mental, moral and social well-being of all working people and to maintain them at the highest levels, to prevent damage to the health of the employees due to work conditions and harmful substances used, and to place them in places suitable for the physiological characteristics of the worker, to adapt the work to people and people It is the medical science that deals with it as a medical science (International Labour Organization, n.d.; "World Health Organization," 1954) According to the ILO's recommendation numbered 112, the purpose of worker health is;

- To maximize the health capacity of employees,
- To prevent deterioration of health due to adverse working conditions,
- To employ every worker in jobs suitable for their physical and mental abilities,

- To achieve the most appropriate productivity with the least fatigue by harmonizing the work and the worker (*Recommendation R112 - Occupational Health Services Recommendation, 1959 (No. 112)*, n.d.)

Unfortunately, in the world where all these goals and policies are produced, according to ILO data (Creating Safe and Healthy Workplaces for All, Laborstat); Every 15 seconds, 160 workers have a work accident, about 6,400 people die every day due to work accidents or occupational diseases, and approximately 350 thousand people die from work accidents and 2 million people from occupational diseases every year.

It is an important fact that occupational accidents result in death or injury, as well as causing heavy economic burdens on society. It is estimated that the annual cost of work accidents and occupational diseases to the world economy is 2 trillion 680 billion Euros, and the cost to the European Union countries is at least 476 billion Euros (Elsler et al., 2017). In order to reduce these results that bring both material and moral burden, it is necessary to increase the effectiveness of scientific studies as well as new policy proposals on occupational health and safety.

When the ILO data on occupational health and safety in construction, which is the subject of the study, are examined, it is observed that there are quite high numbers of work accidents in the construction sector, which has an important place in terms of employment all over the world. Despite the increase in mechanization in the sector, manual labor still plays a major role. According to ILO figures, there are approximately 60 thousand fatal accidents in the construction industry all over the world every year, and according to this, one person dies every 10 minutes as a result of a work accident. For this reason, scientific publications produced for occupational health and safety in construction were examined and analyzed.

3. LITERATURE REVIEW

The construction sector is a dynamic sector in which people from different education levels and different occupational groups are employed (Romero Barriuso et al., 2021). Since the start of a job in construction works depends on the progress and completion of other works and some works must be carried out simultaneously, the business lines that make up the components of the sector are in constant interaction. This situation not only increases the number and variety of possible accidents, but also makes the control and inspection of the working environment and employees and occupational health and safety legislation even more important.

Occupational safety legislation has three main sides: the state, the employer and the employee. In order to provide a healthy and safe work environment, the obligations of the employer and employees are stipulated in laws, regulations and other legislation. However, legal regulation by the state alone is not enough. Achieving the purpose of these legal regulations is possible by gathering the main parties on the common ground of adopting the safety culture and adapting this culture to the business environment. However, when most work accidents are examined in their own essence; Continuing to work in an unsuitable environment for reasons such as either the employer avoids the costs of ensuring occupational safety, ignores the precautions, thinks nothing will happen, forces the employees to produce quickly in order to complete the work quickly (Teran et al., 2015) or because the workers see the current danger but fear of losing their job. As a result of this, it is seen that dangerous situations and dangerous actions are experienced, and accidents are experienced along with the chain of neglect.

The number of accidents and accident-related deaths that occur in the form of falls from height in construction works are among the first among the deaths due to occupational accidents all over the World (Dogan et al., 2021; Janicak, 1998; Lipscomb et al., 2003). Safe working at height depends on many factors such as physical and mental characteristics of the person, education, experience, employer's safety culture, economic

conditions, and administrative factors (Kaskutas et al., 2010a). The importance of falling from a height is mostly due to lack of experience and education and that people who will work at height should receive training before starting work is emphasized in studies on the subject (Antonucci et al., 2010; Dogan et al., 2021; Kaskutas et al., 2010a, 2010b). In the study of Sa et al., the effect of behavioral differences on the rate of falling from height in roof work, which is a line of work that requires working at height, was investigated, and it was concluded that the probability of falling in residential construction workers was greater (Sa et al., 2009). In the study, it is seen that fall protection measures, use of personal protective equipment, type of work, company size, and race / ethnicity variables are significantly associated with fall from height accidents. Roofers have a higher risk of fatal falls from height than other workers (Kines, 2002). In the study, it was emphasized that the fall from the roof resulted in serious injuries, usually in the morning hours, and the fatal injuries mainly occurred in the afternoons and the lack of personal protective equipment such as passive safety nets and seat belts.

In addition to falling from a height in the construction industry, accidents caused by electrical contact are also mostly fatal accidents. Contact with live electrical wires, equipment and lighting fixtures, contact with overhead power lines, contact with energized metal objects, machinery, power tools, and portable lights are all causes of electrical accidents in construction (McCann et al., 2003). Dan Bracken et al. conducted a study on the resistance and strength of boots, which are personal protectors against the risk of coexistence of water and electric current in the working environment, with dry and wet, low and high voltage variables (Dan Bracken et al., 2010). It has been stated that the boots used in the study deteriorate at much lower voltage in wet conditions than in dry conditions, and leakage current protectors are important for currents of 50mA and below.

Another type of accident that workers are exposed to in construction is accidents related to construction machinery. In the literature, it is seen that accidents caused by construction equipment are not as frequent as falling from a height, and therefore, it has not been studied as much as falling from a height (Gürcanli et al., 2008). Machine-related accidents can be largely prevented by the use of personal protective equipment and machine safety equipment (Bull et al., 2002).

Head injuries due to both falling from a height and objects falling from above are common injuries in construction. According to the nature of the work, personal protective equipment must be included in the personal protective equipment and it must be used. The use of personal protective equipment is closely related to the safety culture of the worker. In a study in which the results of the survey conducted with 70 male workers at 2-6 month intervals, before and after the training were evaluated by chi-square analysis, it was found that there was a significant decrease in personal reported injuries after the training, and that sixty-six percent of the workers who participated in the survey learned the information in the post-training safety workbooks. and their colleagues (Williams Jr. et al., 2010). The data obtained as a result of the 24-week study conducted to evaluate the impact of first aid training on their understanding of occupational health and safety risks and risk controls and their motivation to avoid occupational injury and illness, enables workers to realize that their own behavior is an important factor in avoiding occupational injury and illness. Assistance training has also been found to reduce participants' willingness to accept their current OSH risk level.

Dust exposure in the drywall industry and risk perceptions of company owners were measured through 264 interviews with 857 companies. It was found that 8 out of 9 dust samples exceeded the dust exposure limit, and the risk perceptions of the company owners towards worker health were lower than expected(Young-Corbett & Nussbaum, 2009). Mining, crushing, grinding, blasting and construction are high-risk activities for exposure to crystalline silica, especially in developing countries (Demircigil et al., 2010; Shepherd et al., 2008). He worked on respirable dust and crystalline silica exposures

during concrete cutting and grinding activities (Croteau et al., 2002). Artificial and mineral fiber exposures of those working in roofing and asphalt work in the construction industry increase the risk of lung cancer (Pohlabeln et al., 2000). The construction industry is one of the sectors where asbestos-induced lung cancer cases are common (Ahn & Kang, 2009). Wall and floor tile work (Lange & Thomulka, 2000), insulation work (Burdorf et al., 2003), sheet metal workers (Dement et al., 2009; MacArthur et al., 2009; Rushton et al., 2008), Asbestos exposure of workers in roof removal and asphalt work (Stern et al., 2000) and occupational diseases caused by asbestos have also been studied (Pohlabeln et al., 2000). Anthropological studies on the use of respirators have been conducted on 3000 subjects in China, and linear regression analysis has been applied to evaluate the possible effects of gender, age, occupation, and body size on facial dimensions (Du et al., 2008; Trimpop et al., 2000).

In the literature, besides the studies on occupational exposure, there are also studies in the context of risk assessment in occupational health and safety. As it is known, the multiplicity of business lines in the construction sector also increases the diversity of accidents. Identifying existing risks with appropriate analysis methods is the most important step in taking precautions against risks (Aminbakhsh et al., 2013). The types of risks and risk levels that each analysis method can identify are different. There are methods that cannot identify very high and very low risks. Due to the diversity of work items, the use of a single risk assessment method in construction works may not reflect the truth. In this direction, in a study conducted to determine the most suitable analysis method for construction works, 10 different analysis methods (INSHT, ANACT, THREP, SHERPA, RNUR, EVENT TREE, LEST, FINE, ERGONOMIC ANALYSIS and PSYCHOSOCIAL FACTORS) were compared together with their results. It has been concluded that if the risk assessment method is used, the results do not fully reflect the reality, therefore it is necessary to create a new risk assessment methodology for construction works (José & De Los Pinos, 2017). In another study, although the Probability-Impact risk model is dominant in construction works, it was emphasized that the method should be improved in order to obtain a realistic project risk level due to the complex nature of the works (Taroun, 2014).

Statistical analyzes have been included in the studies on the types, distributions, and precautions to be taken of occupational accidents. Anova (variance) analysis is one of the methods used to test whether there are significant differences between data groups. In a study in which the occupational accidents that occurred in the Taiwan construction sector between 2000-2007 were analyzed by the Anova method and the results were evaluated, it was found that the accident occurred on the 1st working day at the workplace due to a weak health and safety policy and work without protective equipment (Cheng et al., 2010). Anova analysis has also been used to determine the possible causes of occupational accidents involving foreign workers in Taiwan, and the results of the study are mentioned as the results of the study, which are caused by employers, inadequate health and safety measures, and insufficient danger awareness of foreign workers (Cheng & Wu, 2013). Occupational injuries were examined through a cohort analysis of data obtained from the employment insurance payment records of legally registered workers who immigrated to Taiwan from foreign countries between July 1, 1991 and December 31, 1993, and found that foreign workers had a lower risk of injury than domestic workers in Taiwan. It has been found that most of the injuries occur in the first 6 months of employment, and that the risk for female migrant workers, especially in the construction sector, is significantly higher than for Taiwanese female workers has been the subject (Wu et al., 1997). By making a cohort analysis of 732,460 occupational accident data experienced in Poland between 2008 and 2018, the relative occupational accident risk of employees in all age groups and the tendency of possible risk changes were determined as a function of time and the group with the highest average relative accident risk in the workplace was found to be 18-19. It has been observed that there is an increase in relative risk among employees in the +60 age group, the smallest relative risk is among employees under the age of 18, who are mostly trainees and students

(Nowacki et al., 2021). In addition to statistics, another frequently used method is the fuzzy logic method. It is very important to be able to predict possible accidents and possible injuries in a work environment (Hallowell et al., 2017). In a study in which all risk parameters were evaluated, the Holistic Occupational Health and Safety Risk Assessment Model (HOHSRAM) was developed based on the integration of logarithmic fuzzy logic, interval-valued Pythagorean fuzzy TOPSIS and gray relational analysis (Mohandes & Zhang, 2021). In another study, in which the fuzzy logic approach was used to measure the risk of occupational accidents, it was seen that the risks could be determined quantitatively with the fuzzy logic method and the method could suggest the most efficient measures (Murè & Demichela, 2009). It is seen that the fuzzy logic method is also used in the development of a premium rating model in order to determine the most appropriate price by the insurers for the compensation insurances purchased by the employers regarding the compensations paid to the workers after the occupational accidents (Imriyas, 2009).

Another noteworthy study topic in the literature about occupational health and safety in the construction sector is risk factors. Working overtime in construction works is one of the risk factors. In a study conducted to determine whether occupational accidents are related to how many hours were worked in the previous shift, it was determined that workers who worked more than 64 hours in the week before the shift had an 88% higher risk compared to those who worked 40 hours or less (Vegso et al., 2007). In another study conducted with 1,260 male workers from 24 construction sites, serious smoking and alcohol consumption, lack of safety training, and depressive symptoms were identified as risk factors for non-fatal injuries (Zheng et al., 2010).

Musculoskeletal disorders (MSD) are injuries and diseases seen in the construction industry (Rwamamara et al., 2010). In the study investigating the psychosocial and physical risk factors associated with the formation of musculoskeletal disorders, it was found that the need for physical work in construction works is the most important risk factor, and monotonous work, high perceived workload and time pressure are also associated with the occurrence of musculoskeletal system symptoms. (Sobeih et al., 2009). In the study on the effects of waist extensors in manual lifting tasks, when the floor is slippery and muddy, a repetitive lifting task was performed on 10 participants for an 8-minute period, ground reaction forces and whole body kinematics were used using a force platform and magnetic motion tracking system. Finally, fatigue and a significant decrease in the median frequency of bilateral erector spine muscles were observed (Shu et al., 2005). The study examining the relationship between occupational exposures and the risk of multiple myeloma of 365,424 male construction workers followed in Sweden between 1971 and 1999 was conducted by applying Poisson's regression to 446 myeloma subjects and there was an increased risk among construction workers exposed to diesel exhaust. While there is no evidence of increased risk associated with other occupational exposures, including asbestos, asphalt, cement dust, metal dust, mineral wool, organic solvents, stone dust and wood dust, occupational exposure to diesel exhaust in the Swedish construction industry may pose a small risk of multiple myeloma (Lee et al., 2003). In another study examining the occupational exposure of engineers working in the construction industry to diesel exhaust, asphalt and welding fumes, silica dust, ionizing radiation and coal tar pitch, the US proportional cancer mortality was used as a reference, and statistically significant high mortality was observed for lung and bone cancers (F. Stern & Haring-Sweeney, 1997). Exposure of construction workers to low-frequency magnetic fields is known to increase the risk of dementia (Seidler et al., 2007). Eye injuries are also an important type of injury. In a study of workers' compensation data from 1994-2003 in the state of Kentucky, the highest rates of eye injuries per 10,000 people were found in the construction industry, particularly in jobs requiring intensive manual labor, with increasing employee training, ensuring the use of effective eye protection equipment, and developing workplace safety cultures. It has been emphasized that occupational eye injuries can be reduced (McCall et al., 2009). In construction works, especially mold workers, it is necessary to work by wearing

protective glasses against the dangers of nails and splinters. However, workers prefer to work without protection due to reasons such as lack of comfort and fit, and fogging and scratching of glasses (Lombardi et al., 2009).

4. METHOD

The research was carried out with the method of systematic literature review (Tranfield et al., 2003). Our study aims to evaluate the contribution of the occupational health and safety literature in construction areas to the development of future studies in parallel with the method in question. In addition, bibliometric analysis was performed with the help of VOSviewer software to support the systematic literature review and to obtain comprehensive information about past studies. At this stage, the bibliometric analysis was designed and visualized according to four basic criteria: textual data, keywords, sample size and authors who are the pioneers of the field. In summary, Vosviewer is a text mining application developed to make inferences from data stacks in line with a certain focus (Arts, 2020). Vosviewer is a software for converting common words in more than one text into visual maps. With this software, it is possible to reveal the relations between the outputs obtained from the texts analyzed in both graphic-based and distance-based maps and the strength of these relations (van Eck & Waltman, 2010).

The sample of the study consists of 162 articles published in journals that were prepared with the focus of occupational safety and scanned in the web of science database between 1996 and 2020. To reach the sample, the database was scanned using the keywords "construction, construction workers, occupational health and safety". Due to the publication of the legislation on "Health and Safety in Construction" prepared and implemented in England in 1996, the start date of the study was determined as 1996. One of the primary purposes of the study is to follow the researches made since this date and their focal points over time. Only publications written in English and in article format were included in the study.

5. FINDINGS AND ASSESSMENTS

5.1. Distribution of Studies by Years

It is seen that the studies in the field have an upward trend until 2010. 2010 is the year in which 162 articles reached the highest number of publications on a yearly basis. With the rapid decrease in the number of publications after 2010, it is noteworthy that there was no study between 2011 and 2014 that included the keywords of construction, construction workers, occupational health and safety (Chart 1). Although it does not have a high acceleration as in the 1996-2010 period after 2014, it can be said that the studies in the field have a tendency to increase again.

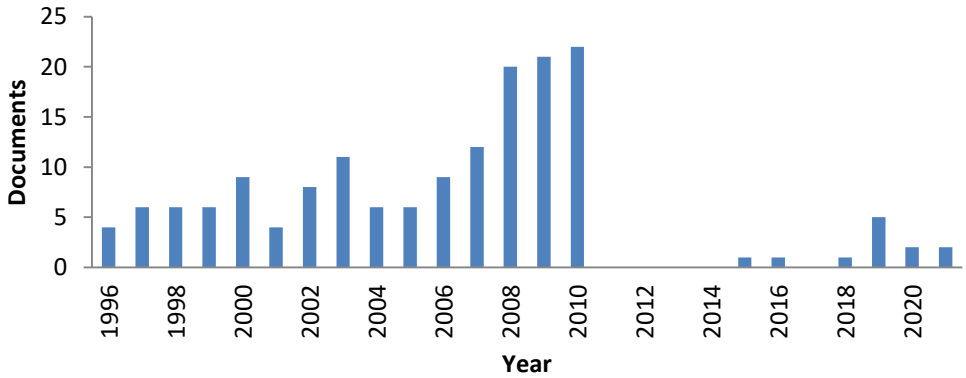


Chart 1: Distribution by years

5.2. Featured Researchers

The researchers with the most studies in the field are given in Graph 2. According to this graphic, the most research done in the field belongs to Jessica Bondy and Richard Neitzel

with 6 studies. Bondy has worked on the loss of working days caused by occupational accidents, risk factors that cause injury, liability insurance, injury distribution due to accidents (J. Glazner et al., 2005; JE Glazner et al., 1998, 1999; Lowery et al., 1998, 2000; McDonald et al., 2009). As for Neitzel; It is seen that construction workers generally work on noise exposure, including the relationship of ear protectors used against noise with education, the level of ear protection use of workers, and the relationship between the nature of the job and the noise exposure (Edelson et al., 2009; Neitzel et al., 1999, 2004, 2008; N. Seixas et al., 2005; NS Seixas et al., 2001)

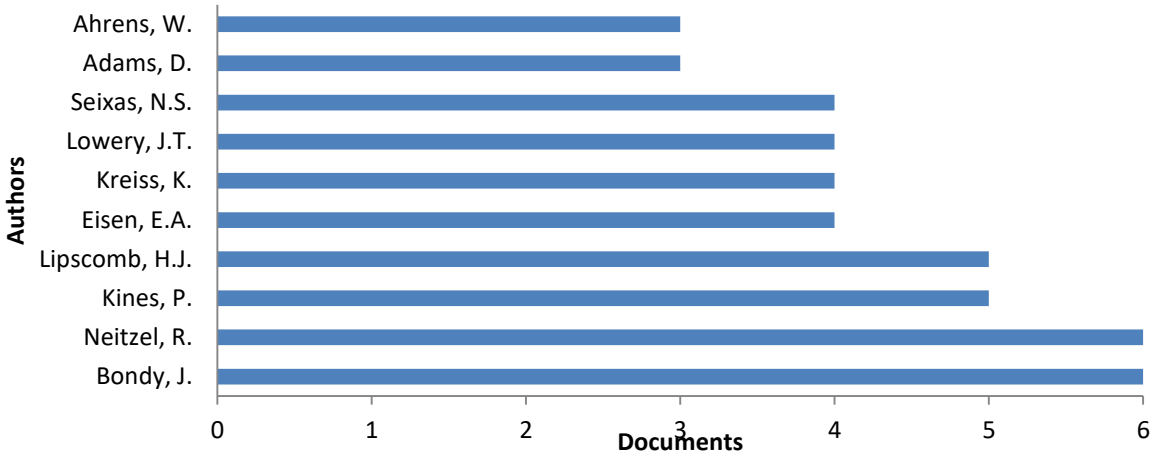


Chart 2: Sorting by Authors

5.3. Featured Scientific Journals

Another analysis of the research was carried out regarding the journals in which studies on worker health and safety in construction were published. In this direction, the journals with the most research in the field of study are given in Chart 3 as American Journal of Industrial Medicine, Journal of Safety Research, Journal of Occupational and Environmental Hygine, Annals of Occupational Hygiene and Journal of Occupational and Environmental Medicine. While the number of publications in the American Journal of Industrial Medicine increased in 1997 and 2010, the publications in the Journal of Occupational and Environmental Hygine increased in 2008, the publications in the Annals of Occupational Hygiene in 2004, and the publications in the Journal of Safety Research in 2002 and 2009. It was observed that the number of publications in the Journal of Occupational and Environmental Medicine remained constant over the years.

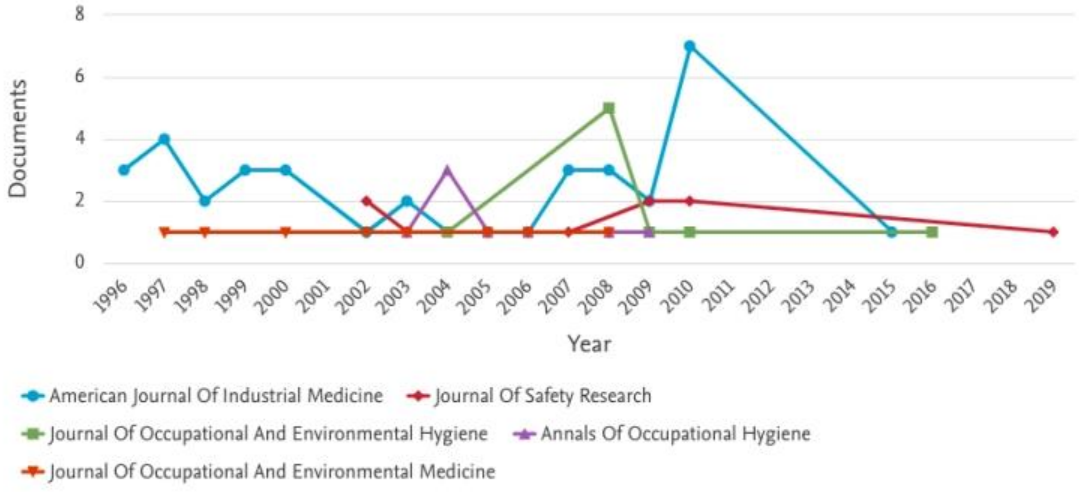


Chart 3: Distribution by source and years

5.4. Active Countries

The ranking that emerges when the countries (United States, Denmark, Germany, Spain, Sweden, United Kingdom, Australia, Finland, Canada, China) where the authors of a total of 162 articles are located are given in Chart 4. Accordingly, the USA ranks first with 106 studies, followed by Denmark, Germany and Spain with 10 studies each. The number of studies in other countries is less than 10.

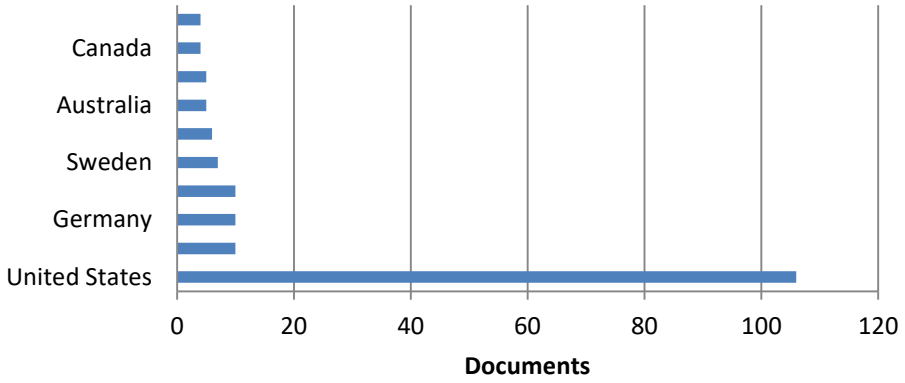
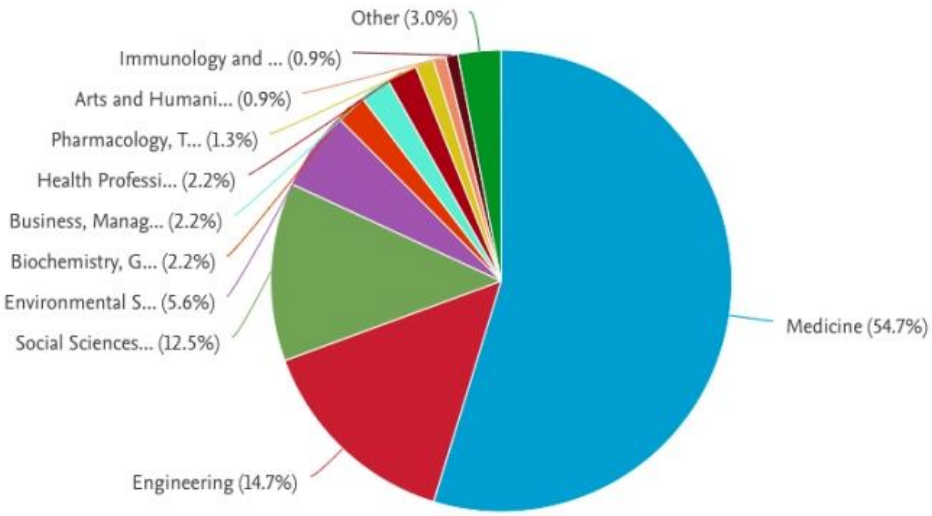


Chart 4: Distribution by country

5.5. Disciplines

It is seen that 127 studies, corresponding to 54.7% of the 162 studies constituting the sample, were carried out by researchers from the medical field. It is followed by the engineering field with 34 studies with a size of 14.7%. Social sciences is the group that has made the third largest contribution to the field. 12.5% of 162 studies with 29 articles are in this field.



Graph 5: Distribution by study areas

5.6. Text Analysis and Visualization

Through VOSviewer, a frequently used scientific map visualization tool, 162 articles were analyzed to establish bibliographic links. The text mining and image mapping software suggested a total of 1829 different keywords from the selected articles. However, after the data set was eliminated to include words that were mentioned at least five times in the sample, 176 keywords were found suitable to pass the threshold. These keywords were re-evaluated by the authors considering their total link strength values and the

main focus of the study. In this step, descriptive terms related to examples of previous studies and terms specific to other disciplines are omitted from the list. For this reason, the data set was created using a total of 133 keywords that only include occupational safety and health of construction workers. The results show that the studies conducted between 1996 and 2020 in the field of occupational health and safety in construction works are gathered around 6 clusters (Figure 1: Clusters and their subcomponents and Table 1: Clusters and their subcomponents). In the map created with VOSviewer, the distribution of keywords under these 6 clusters (occupational exposure, occupational accident, risk assessment, occupational risks, risk factors, industry) reveals the link between the strength of values and keywords.

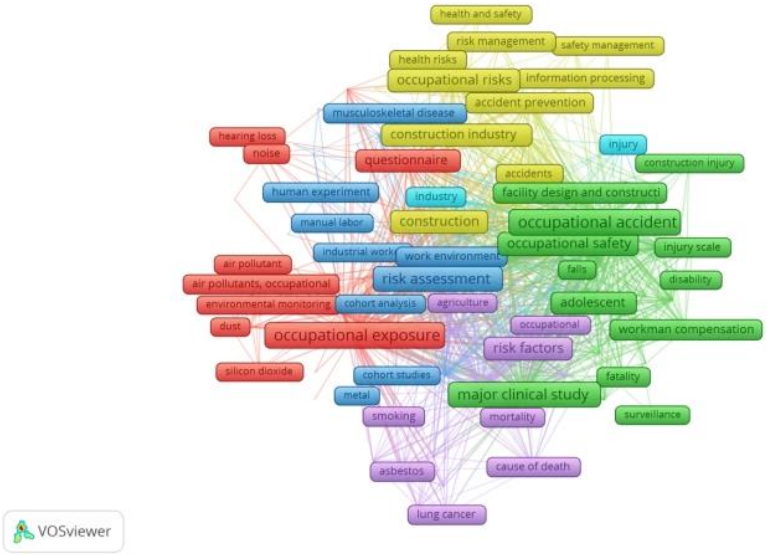


Figure 1: Clusters and their subcomponents

Table 1: Clusters and their sub-components (6 clusters formed by 133 keywords in Figure 1 are presented in different colors coded).

Cluster 1 Occupational Exposure	Cluster 2 Occupational accident	Cluster 3 risk assesment	Cluster 4 Occupational risk	Cluster 5 risk faktors	Cluster 6 industry
Air pollutant	Absenteeism	Biomechanics	Accident prevention	Aged	Construction work
Building materail	Accidents, occupational	Body posture	Accidental falls	Agriculture	Construction worker
Carpenter	Adolescent	Cohort analysis	Accidents	Asbestos	Economics
Construction materials	Building industry	Cohort studies	Attitude to health	Cancer risk	Health survey
Construction work	Construction injury	Ergonomics	Construction	Case-control studies	İncidence
Construction workers	Disability	Health hazard	Construction industry	Cause of death	İndustry
Controlled study	Facility design	Heart rate	Employment	Epidemiology	İnjury
Dust	Falling	Human engineering	Focus groups	Lung cancer	Occupational diseases
Environmental exposure	Falls	Human experiment	Health and safety	Lung neoplasms	Socioeconomics
Environmental monitoring	Fatality	İndustrial worker	Health knowledge	Mortality	Worker
Exposure	Health insurance	Job performance	Health promotion	Occupation	Workplace
Exposure assesment	High risk population	Manual labor	Health risks	Occupational	Young adult
Hearing loss	İncidence	Metal	İndustrial hygiene	Occupational cancer	
Hydrocarbons	İnjury scale	Muscoloskeletal diseases	İnformation processing	Occupational diseases	
İnhalation	Major clinical study	Occupational hazard	İnjuries	Occupations	
İnhalation exposure	Occupational accident	Personnel	Occupational Health	Risk factors	
İnterview	Occupational injury	Risk assesment	Health risks	smoking	
Lead	Occupational safety	Sex differance	Residential		
Noise		Tax performance			
		Work			

Occupational exposure Protective devices Protective equipment Questionnare Risk	Poisson distribution Retrospective studies Surveillance Traffic accident Workers' compensation Workman compensation Wounds and injuries	Work environment Work schedule Working time workload	construciton Risk management Safety Safety management training		

Cluster 1: The keywords gathered under the heading "occupational exposure", which are seen to have the highest frequency, have been the focus of attention of researchers working in the field of occupational health and safety in construction works. Respiratory air pollution (Demircigil et al., 2010; Lofgren, 2008), Hydrocarbon (Anderson et al., 2008; Brüske-Hohlfeld et al., 2000; Marczynski et al., 2009), dust (Kauppinen et al. ., 2006; Shepherd et al., 2008; Young-Corbett & Nussbaum, 2009), asbestos (Ahn & Kang, 2009; Dement et al., 2009; Rake et al., 2009), as well as noise exposures (Edelson et al. ., 2009; Hong, 2005) have been studied extensively. This situation coincides with the fact that the researchers, who constitute 54.7% of the sample of the study, are from the field of medicine. The effects of respiratory and hearing exposures on human health were investigated.

Cluster 2: The second cluster consists of the components gathered under the title of "occupational accident". Researchers working on falling from a height, which is the most common type of accident in construction workplaces, examined the effects of employees' behavioral characteristics on the accident (Kines, 2003), the attitudes of personal protective use (Sa et al., 2009), the place of education in fall from height accidents (Kaskutas et al., 2010a, 2010b), employees' perceptions of the risk of falling from a height (Antonucci et al., 2010), and the severity of injuries resulting from falls (Gillen et al., 1997). Compensation and insurance payments after accidents have also been studied (McDonald et al., 2009)

Cluster 3: The third cluster has the title of "risk assessment". In studies with keywords belonging to the risk assessment cluster, mostly ergonomic risks are evaluated (Park et al., 2009), and the effects of construction works on the musculoskeletal system of workers are examined (Nussbaum et al., 2009; Rempel et al., 2010; Rwamamara et al. , 2010; Welch et al., 2009). Risks were also analyzed by gender (Brogmus, 2007; Morrell et al., 1998) and age (Rabi et al., 1998). There are also studies evaluating the relationship between working hours and work schedule and injuries (Dembe et al., 2008; Gold et al., 2006; Vegso et al., 2007).

Cluster 4: The fourth cluster is "occupational risks". Researchers investigating the risks faced by workers working in any line of business in the construction industry, occupational risk prevention training (Romero Barriuso et al., 2018), variables affecting occupational risks (Rabi et al., 1998), risks on health. effects (Kauppinen et al., 2009; Samkange-Zeeb et al., 2010), estimation methods of occupational risks (Bull et al., 2002; José & De Los Pinos, 2017). Researchers working in the field of health; Occupational risks, employees' cancer, brain timor, mesothelioma, asbestosis (Ahn & Kang, 2009; Burdorf et al., 2003; Dement et al., 2009; Rake et al., 2009; Rushton et al., 2008) estimating the leading occupational risks of the industry, suggesting methodologies to improve working environment conditions (Cortés-Pérez et al., 2020; Flynn & Susi, 2010; Murè & Demichela, 2009), researchers working in the social and human fields. On the other hand, it is seen that they deal with insurance, loss of labor, loss of working days, compensation (Brogmus, 2007; JE Glazner et al., 1998; Kines et al., 2007).

Cluster 5: The fifth cluster includes 17 sub-components under the heading "risk factors". The keywords asbestos, cancer, occupational disease, Lung neoplasms, etc. under the cluster are in line with chart 5, that is, most of the researchers are from the medical field. Among the articles constituting the sample, 35 articles with the keyword "epidemiology" or published in journals in the field of "epidemiology" were found, in which the effects of risk factors on human health were investigated.

Cluster 6: The sixth cluster has the title "industry" as the smallest cluster. Since the dataset of the study was created using a total of 133 keywords, including only the occupational safety and health of construction workers, the keywords related to the construction industry draw attention under the "industry" cluster. Studies were conducted on construction workers, the types of occupational cancer were analyzed according to the socioeconomic status of the workers (Baradan et al., 2019; Ji & Hemminki, 2005), the relationships between occupational injuries and deaths and variables such as age, occupation, and gender were examined (Chau et al., 2019; Ji & Hemminki, 2005). ., 2004; Marsh, 2001; Nowacki et al., 2021), there are studies examining the tendency and attitudes of construction workers to use personal protective equipment (Bull et al., 2002; Kines, 2002; Lombardi et al., 2009).

6. RESULTS

In this study, the publications indexed in the Web of Science Core Collection on "occupational health and safety in construction works" were examined and analyzed by scientific mapping method. Bibliometric analyzes were used by Hulme in 1923 as a statistical bibliography term in the census of documents, then by Raising in 1969 on citation in health sciences, and in 1969 the term bibliometrics was defined in the Pritchard study (Pritchard, 1969; Hulme, 1923; Raisig; 1962). Today, bibliometric analyzes are frequently used both in the evaluation of scientists, institutions and journals, and in the creation and research of science policy. Thanks to these analyzes, individuals, institutions and disciplines can be evaluated comparatively and it can also help to identify potential issues that have not been studied in the literature. The point that should not be forgotten here is that bibliometric studies are a quantitative evaluation and do not provide a qualitative review of the content. In this study, using the Web of Science Core Collection database, a search was made with the keywords "construction, construction workers and occupational safety". country, journal, publication year, number of publications, publication type, publication language and subject trends were examined in the context of universities that supported the research and the "VOSviewer" program was used to define it with bibliometric analysis. The strategic diagrams created and the evolution map clearly show which are the most studied themes.

Another striking result of the analyzes is the low number of researchers working on occupational health and safety in the construction sector. Considering that the Occupational Health and Safety discipline is an interdisciplinary field, there is a need to conduct studies on this subject in all disciplines and to carry out incentive and awareness studies by both universities and state institutions to associate them with their own fields. In addition, the limited number of countries (United States, Denmark, Germany, Spain, Sweden, United Kingdom, Australia, Finland, Canada, China) where the authors of the 162 articles reviewed is one of the reasons for the low number of researchers in the field. Studies on occupational health and safety in construction are carried out in very few countries. However, this issue is a global problem that the whole world needs to produce solutions together. With the provision of various directions and incentives in scientific studies on the subject by the state and universities in all countries, more countries should conduct effective research and more researchers should be interested in this subject.

In the analysis made in the study, the keywords were distributed under 6 clusters. These clusters are occupational exposure, occupational accident, risk assessment, occupational risks, risk factors, industry. The low number of researchers, publications and countries

conducting research on Occupational Health and Safety in Constructions has caused these clusters to be limited. It is thought that as the number of studies increases, related clusters and related areas will increase and more effective methods can be developed by associating occupational health and safety in construction with many disciplines. When these clusters were examined, it was observed that many potential subjects such as occupational health and safety education, virtual reality technologies, electroencephalography, legislative studies, etc. were not studied.

When the literature is examined, many articles on "the importance of education in occupational health and safety" have been observed. However, among the articles constituting the sample, there was no study examining the integration of "virtual reality" technology into education and its effects, especially in terms of engineering science and researchers. The studies to be carried out using these technologies will have a positive effect on increasing the awareness and knowledge of the workers about the risks of accidents without being exposed to work accidents in real life. These technologies are among the potential subjects that can play an active role in both the discovery of occupational diseases in the field of medicine and the prevention of occupational accidents in the field of engineering.

Yet another potential issue emerges as "the effects of stress levels of construction workers on occupational accident risks". In addition, the concepts of occupational health and safety are a whole, and the mental and physical health of the employee forms the basis of safe movement. An employee who is not mentally and physically healthy cannot be expected to comply with the measures taken and to work in a controlled and safe manner. With this approach, considering the negative effects of stress on human movements and behaviors, studies on the relationship between stress and risk by analyzing the measurement of real stress levels of employees in the construction sector will be beneficial in taking precautions against frequent accidents in the sector. With a wearable electroencephalography (EEG), multidisciplinary studies by researchers from medicine, engineering and even humanities on monitoring the brain responses to stress of those working in the construction industry will make a significant contribution to the field. Again in the multidisciplinary field, the "thermal camera", which allows the identification and monitoring of the instantaneous mood state depending on the changes in the body temperature of the individuals' blood flow, heart rhythms and muscle-based actions, is among the subjects that have not been studied in the field of occupational health and safety. In addition, studies that will clarify the problems encountered during the practical application of the legal regulations, which include the rights and responsibilities of the worker-employer, to public employees and interns, have not been found in the literature review. The aforementioned legislative studies also appear as another potential issue. As a result, it is thought that this study is important for future studies in terms of presenting a comprehensive literature review on occupational safety in construction works.

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