

## WHAT IS THE EFFECT OF THE PANDEMIC ON OCCUPATIONAL HEALTH AND SAFETY?: A SYSTEMATIC REVIEW LITERATURE

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### Abstract:

Awareness of occupational health and safety risks in the construction industry has increased significantly. However, during the COVID-19 pandemic, the construction sector was one of the first sectors to be affected and has experienced a high increase in the spread of the virus. This study uses a systematic review method using the PRISMA method, which includes the definition of keywords and their synonyms that are relevant to our subject. The results of this study are the impact of work safety practices that occurred during the pandemic including: maintaining physical distance between employees, one worker doing only one job, supervision through innovative technology, and spraying disinfectant on work equipment after finishing work.

**Keywords:** Construction, OSH, Covid 19, Construction Industry

### 1. INTRODUCTION

Indonesia is a developing country that is booming with development in the construction sector. Construction projects have a distinctive nature, workplaces in open spaces that are affected by a limited period of work as well as jobs that require a lot of energy, weather, and use work equipment [1]. Construction projects with their unique and different characteristics often put workers at risk. The risk factors for construction projects are so large that they often cause construction work accidents [2], [3]. The results of research data by the International Labor Organization (ILO) show that the rate of work accidents in developing countries has a higher impact value than other industrialized countries. In addition, occupational accidents and diseases that occur in developing countries are in the field of construction work [4].

Based on these unique characteristics, the construction services sector has a risk of major to fatal accidents. Construction work has a very large number of work accidents, as evidenced by Employment data, by the end of 2019 there have been more than 100,000 work accidents [5]. Meanwhile, for serious accidents that resulted in the death of around 2,000 deaths from all work accidents [6], [7]. The complexity of implementing a construction project that involves a very large amount of manpower, equipment, and materials, either working individually or together between these resources can be a source of work accidents [8]. These accidents can hamper the process of construction work so that in achieving management goals the construction project does not run optimally, besides that the progress of work and contractor performance has decreased and is hampered [9], [10].

The jobs that can be said to be the most dangerous are work carried out at heights and work carried out by excavation [11], [12]. In both types of work, work accidents that occur are often fatal and can result in permanent disability or even death of the victim. Falling from a high

place is a very big risk that can occur to workers when carrying out construction activities at heights. Meanwhile, construction workers are not paying attention to these risks with frequent personal fall arrest systems which have actually been regulated in the construction K3 guidelines [13]–[20].

To prevent accidents, an OHS Management System that regulates and can be implemented [21]. The high and low implementation of the company's K3 will affect work productivity [22], because a safe and comfortable work atmosphere will create good quality work for employees to achieve goals [23]. Occupational Health and Safety (K3) are two important things [24], [25]. Therefore, all construction companies are required to provide all necessary equipment and Personal Protective Equipment (PPEP) for all workers [26]–[28]. This is mandatory for a worker who works in a construction environment [29], because in the process there may be accidents or hazards that may occur in the process [30].

Improving the quality of work life of employees can also have an effect on increasing work productivity [31]. The quality of work life is an issue that deserves the company's attention. K3 also affects work productivity [32]. Work productivity is the ratio of the output produced to the input issued. If the company does not implement K3 properly, the work productivity and company profit will decrease.

To support the company's operations cannot be separated from project activities. Many series of activity stages, starting from the design stage, construction stage, trial stage to the operation and maintenance stage make the level of accident risk and PAK has a high possibility [33]–[35]. The OSH program is a very important aspect in every stage of the project, in order to create a safe, healthy and culturally OHS work environment. There are still work accidents in the category of mild to moderate accidents. Work accidents also affect productivity; therefore work accidents must be carried out in holistic accident prevention and comprehensive pressure management through K3 programs that are developed to increase productivity. Productivity is related to quantity, quality, timeliness, accident rate, compensation costs and work environment. Therefore, construction company managers are currently very concerned about the risks of construction work, especially the risk of injury to construction workers at the project site [36]. Construction work is becoming the most challenging job in the world, because construction workers face a high risk of work accidents in hazardous physical work environments such as working at heights, direct contact with electricity and the risk of exposure to construction materials containing chemicals [26]–[28]. The use of heavy equipment and machinery can cause unwanted fatal accidents. The implementation of good OHS management in construction projects is a form of company responsibility towards worker safety so that it can prevent damage, work accidents, diseases, and create a non-hazardous working atmosphere on construction projects. In countries such as Indonesia and several other developing countries, the management of OHS related to the application of OHS regulations and standards is still far from the ideal standard.

So far the Covid-19 pandemic has resulted in fatal consequences spreading across the country. Many countries are experiencing recessions and declining economic growth [38]–[41]. In addition, regulations are enacted to limit human movement, which of course is very contrary

to the needs of the construction industry where on-site work is still required. Several project personnel must be in place to supervise the work and monitor all activities in the project which of course will greatly affect the productivity of project personnel [42]. Some of the impacts of the pandemic on problems for work, among others, are jobs that are accustomed to conventionally becoming difficult to coordinate with colleagues because they are required to be virtual, it requires a neater work schedule and organization. The main causes of non-compliance with salvation are generally summarized as; the desire to obtain more profits, the misinterpretation that investing in safety increases the project budget, lack of controlling authority, manpower unconsciousness, poor governance system, lack of safety training, and shortage of safety equipment, political influence, and meeting deadlines [23]. The risk of work is higher during the Covid 19 pandemic, as construction work cannot be done remotely and requires direct physical activity in workplaces where workers will interact with each other and the risk of being infected with Covid 19 is even greater [11], [12]. For this reason, good management of Occupational Safety and Health (OSH) is needed so that the risk of work accidents in the construction sector can be minimized [21]. Therefore, the importance of the construction industry to the economy, and an understanding of the potential impact of Covid-19, should be shared throughout the world.

Several studies on the impact of the pandemic on the construction industry have been carried out. Studies in the UK have successfully investigated the effects of the pandemic on the industry in general [43], [44]. Measuring the consequences resulting from the pandemic on the construction industry, both state and private companies in Malaysia, has also been carried out so that very influential factors are obtained, namely project termination, job losses, delays in the completion schedule, increased implementation costs and financial impacts [45] [12]. Research in the UK to determine the positive and negative impacts of the pandemic on the industry has also been carried out [27], [47], [48]. Based on this background, this research will reveal the causes of work accidents in construction companies to the impact during the pandemic.

## 2. MATERIALS AND METHODS

This research was built consisting of four major stages; the details of the major stages are explained separately. The stages and details of the stages will be followed by the implementation method. In the literature search process, the selection of search results is done by filtering the search results based on predetermined criteria. The keywords "Occupational Health and Safety", "Construction Industry", and "Covid-19". The criteria used are inclusion and exclusion, which are then used as the basis for selecting literature. The steps in the search are divided into several processes, namely identification, screening, eligibility, and inclusion. This step is in accordance with the guidelines in PRISMA.

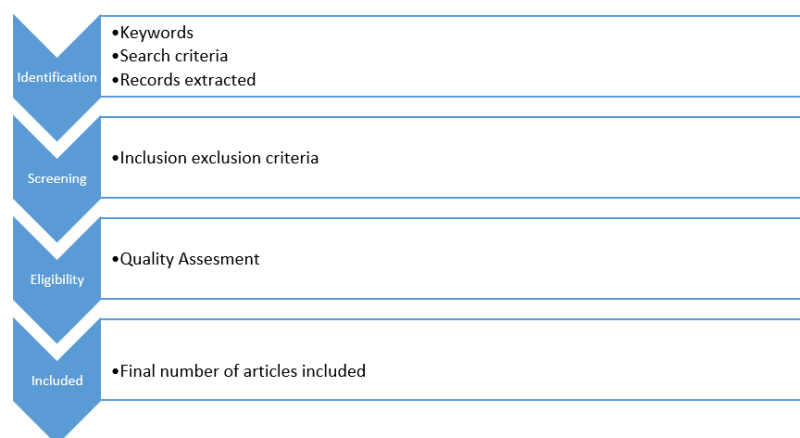
The specific search range is 2018 – 2022 with the reason, and the popularity of the concept of big data began to be widely known starting in 2016. This search is based on the index of the keywords used. In detail, the research program is described in Figure 1. A systematic review is limited to research in the form of articles. The articles used are research articles that have

been reviewed and published in Scopus-indexed English journals. In managing articles obtained from online databases, the author uses Mendeley tools.

At the identification stage, three literature searches are used which will be carried out on an online database that has a large repository for academic studies, namely IEEE Xplore, Science Direct, and Emerald. In the second process of the identification stage, a search is also carried out on the supporting data. The next stage is screening, at this stage, it is divided into three processes. First, determine the string (keyword) to be used in the search. The use of strings used is divided into several phases. In the first phase of the search use the string "Expert" AND "System". After getting the results, the next phase is the search with strings related to data mining. The strings used are seven techniques of data mining. After the tracing process is complete, the next process of screening is filtering duplicate or duplicate data. As well as filtering the title, abstract, and keyword of the article. Exploration and selection of titles, abstracts, and keywords in articles obtained from search results based on previously defined eligibility criteria. The time range based on 2016 – 2022 is included in the screening stage. So that in the final process of this stage, the amount of data used is obtained and is not used for further reviews.

Eligibility data is then processed manually using Microsoft Excel software to group the data. In data processing, there are 5 steps, namely (1) data grouping based on 2018-2022; (2) Grouping of data based on Scopus category; (3) Data processing to determine the research topic. In determining the research topic using the keywords “Occupational Health and Safety”, “Construction Industry”, and “Covid-19”; (4) Summing up the data per research topic; (5) Presenting the results in the form of topic statistics per year. So that we get two parts, namely those that meet the requirements and those that do not meet the requirements. The conditions that must be met in this stage are the suitability of research methods and techniques used in research. The last stage is included, where the data are grouped based on the techniques used and the field of case studies used and the approach used and differentiated based on two types of research methods, namely qualitative and quantitative.

**Fig. 1 – Prisma Framework Method Steps**



In addition to PRISMA, Microsoft Excel software is used to analyze articles that have been obtained. In Microsoft Excel, filters are carried out according to the criteria and gradually to ensure the accuracy and suitability of the article with the discussion.

### 3. RESULTS AND DISCUSSION

#### 3.1 Search Strategy

In this study, a search technique was carried out with a systematic review to be able to find relevant material. The search method on the library review uses the Scopus database. The keywords in the search are Occupational Health and Safety, Construction Industry, and Covid 19. Figure 3 shows the scope of the relevant article's field of study.

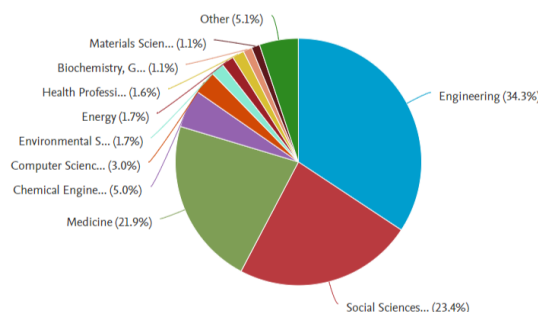


Fig. 2 – Scope of Relevant Article Fields of Study

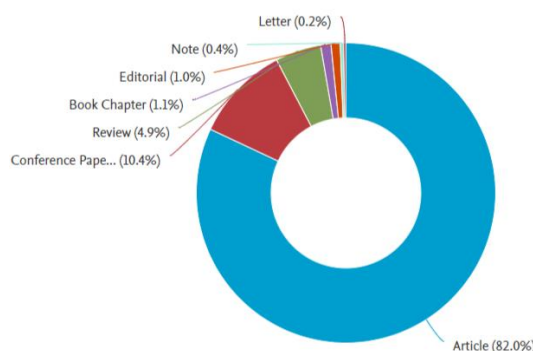


Fig. 3 – Document Type about Topic

The search consists of Scopus indexed journal articles in English with a time span from 2018 – 2022. At this stage, obtained 810 articles.

#### 3.2 Criterias of choice

Prisma Analyses statement was used as a basis in the selection process, specifically for a literature review on the Impact of the Covid 19 pandemic on Occupational Health and Safety in the Construction industry. With abstracts, keywords and article titles about occupational health and safety apat found 810 scopus indexed journal articles in the range between 2018 –

2022. The search results show most of the articles from the field of engineering that discuss the condition of occupational safety and health in the construction industry in different countries of Europe and Asia. The initial document type is still mixed then only used with the document type in the form of scopus indexed Journal Articles only.

### 3.3 Quality Assessment

This literature study depends on the publication of scopus indexed journal articles and to ensure the quality of the article, selection is carried out by further examining the abstract, the article abstract is analyzed and selected thoroughly to ensure that the content of the article is included in the scope of discussion and has high relevance. The next stage is filtering document types, in this regular review lite only used document types in the form of articles. From the initial data of 810 documents there are 664 documents of type Article. So majority types of documents were removed from the list of lit studies. Furthermore, the data was filtered back with the criterion that abstracts, titles and keywords should discuss the Construction Industry and Covid 19, based on these only 206 articles were included in the group. The next filter is articles that use English, as many as 7 article were removed because they used languages other than English. Here is a visualization map of article quality assessmentl

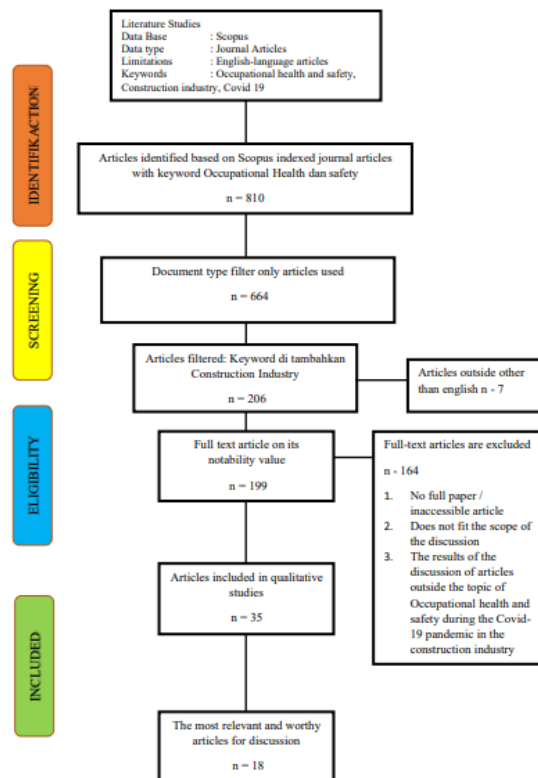


Fig. 4 – Visualizaton Map the Feasibility Assessment Network

### 3.4 Data Extraction

Based on the results of the article feasibility assessment, 18 articles indexed by Scopus were obtained with the following abstractions:

Articles must be original articles and indexed by Scopus, this study does not use or delete data on case study articles, conference articles, articles other than English articles and unaccountable articles. Articles taken from publications between 2018 – 2022 (the most uptodate and widely used articles as references). The article must discuss the impact or condition of occupational health and safety in the construction industry during the Covid-19 pandemic to be able to find out the risk of pandemic work to OHS.

The article shows that Covid 19 has had a significant impact on the construction industry, especially in the field of occupational health and safety, which has an impact on other fields. During the Covid-19 pandemic, we tried to find an approach to characterize the factors and impacts of the Covid-19 pandemic affecting OHS in the construction industry. Research with the method of study literature review to examine how previous research has discussed the effect of Covid 19 on occupational health and safety. Based on 18 most important and relevant articles that show the impact of the covid 19 pandemic, keyword network links, VoS Viewers such as Limiting the number of workers in the process of working on construction projects slows down the progress of construction industry projects to reduce the transmission of Covid 19. So that the extract data is obtained as in table 1 below

**Table 1 – Article Data Extraction**

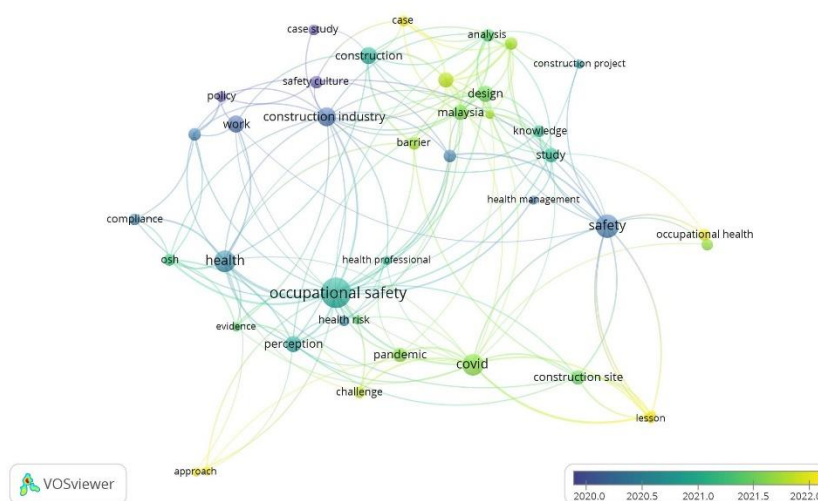
No	Title	Authors/ Year	Data Collection Method	Methodology	Findings
1	The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms	[49]	Semi-structured interviews	Thematic analysis	The results of the study concluded that there was an influence between OHS knowledge and the use of PPE on the occurrence of work accidents.
2	Barriers to the implementation of COVID-19 safety regulations: insight from Ghanaian construction sites	[50]	Open-ended questionnaire	Qualitative research method	The results of the study suggest the need for an in-depth evaluation from the company regarding OHS knowledge and PPE for employees, in order to minimize work accidents in the company.
3	Implementation challenges of COVID-19 safety measures at construction sites in South Africa	[51]	Open-ended interview	A qualitative research approach	The COVID-19 pandemic has forced construction companies to reduce employees. With the decrease in the number of employees, the workload per individual also increases. This can increase the risk to occupational safety and health.
4	Return to work in the context of the COVID-19 pandemic in the industrial and construction sectors in Navarre (Spain)	[52]	Questionnaire	A qualitative research approach	The Covid-19 pandemic has had a significant impact on the construction sector. Implementation elements in the construction sector include

No	Title	Authors/ Year	Data Collection Method	Methodology	Findings
					materials, labor, delivery or transportation processes, time and mobility that are directly related to the Covid-19 outbreak.
5	Impact of Covid-19 on field and office workforce in construction industry	[36]	Literature review	A multi-step research methodology	The implementation of the Covid-19 prevention protocol, the timing of the work, and the cost of carrying out the work have a significant effect on occupational safety and health.
6	Impact of COVID-19 on the US Construction Industry as Revealed in the Purdue Index for Construction	[53]	Data collection	Statistical analysis-SEM and LSTM.	The project has implemented an OHS policy called QPASS Commitment in the project but the implementation has not been maximally tried, structurally it has implemented the organization.
7	Adapting to COVID-19 on construction sites: what are the lessons for long-term improvements in safety and worker effectiveness?	[46]	Semi-structured interviews	A qualitative approach	The implementation of Management Science has not run optimally in practicing communication and information data. the project has conducted training but it is not yet compatible with efforts to prevent work accidents, the implementation of OHS supervision is not yet optimal.
8	Influence between COVID-19 Impacts and Project Stakeholders in Chilean Construction Projects	[54]	Semi-structured interviews	Qualitative content analysis (QCA).	The results of the study show that workers / laborers still have the right to OHS and the consequences, the form of OHS is workers working from home or Work Form Home (WFH).
9	Effects of the COVID-19 pandemic on the construction sector: a systemized review	[55]	Peer-reviewed articles	A systemized review	The study further identified 39 subtopics through detailed content analysis and organizes them into the categories of negative impacts, positive impacts and opportunities and barriers to COVID-19 safety guidelines in the construction sector.
10	Activities of employers and OHS services during the developing COVID-19 epidemic in Poland	[19]	Survey	Data Analysis	To maintain and improve the behavior of the workforce and the implementation of the construction OHS program, it is expected that the workers will follow the standard operating procedures (SOP), the company will monitor, and the relevant agencies will control and evaluate the implementation of OHS.



No	Title	Authors/ Year	Data Collection Method	Methodology	Findings
11	Lessons learned from the impact of COVID-19 on the global construction industry	[56]	Questionnaire	Zoho analytics	Human factors that influence the cause of work accidents in construction companies are failing to identify unsafe conditions that exist before the activity begins
12	Delays and Financial Implications of COVID-19 for Contractors in Irrigation Projects	[57]	Review	Literature Review and data analysis	The existence of uncoordinated OHS planning, the absence of special OHS officers in the field, the management also does not realize the importance of OHS, there are no clear personnel in handling OHS, and there is no emphasis and strict sanctions on the use of personal protective equipment causing an increase in the rate of work accidents in the workplace. construction work.
13	The Impacts of Environmental Practice Characteristics on Its Implementation in Construction Project	[58]	Questionnaire	PLS-SEM	Work environment factors that influence the cause of work accidents in construction companies are the lack and insufficiency of failures in the management of construction sites, procedures, and operational design.
14	Impact of COVID-19 on health and safety in the construction sector	[43]	Review	Literature Review and data analysis	Lack of OHS training, lack of occupational safety and health signs, occupational safety and health signs.
15	Construction safety during pandemics: Learning from the xinjia express hotel collapse during covid-19 in china	[59]	A systematic approach	STAMP	The effect of OHS on construction workers is influenced by several factors, namely knowledge of OHS and worker behavior and work accidents in the workplace.
16	Early Impacts of the COVID-19 Pandemic on the United States Construction Industry	[28]	34 telephone interviews	SMEs	Pressure management and accident prevention contribute positively but not significantly or have a low coefficient value, so to improve or improve the evaluation of the concept of the existing OHS program and OHS in this project it is not implemented.
17	COVID-19 in the Workplace in Indonesia	[60]	Online interviews	Mixed method	The lack of understanding of the relevant parties regarding the importance of OHS and the limited company budget appear to be obstacles in the implementation of OHS in the Project so that the OHS Management System does not run optimally.

No	Title	Authors/Year	Data Collection Method	Methodology	Findings
18	Safety and health management response to COVID-19 in the construction industry: A perspective of fieldworkers	[61]	A questionnaire survey	a quantitative research method	Agencies are still not ready to implement the COVID-19 prevention and control program in the workplace. The suggestion of this research is to be able to increase efforts to prevent and control COVID-19 for all employees and leaders.



**Fig. 5 - Pemetaan article databased on**

The picture above is a collection of research related to the title of the research on the influence of the Covid-19 pandemic on occupational health and safety. The results of the Vos Viewer analysis consist of 3 clusters. Within the scope of the study, occupational safety consists of 9 variables, namely compilation, OSH, health, health professionals, evidence, perceptions, health risks, pandemics, and challenges. In the context of research, the safety group consists of 9 variables including lesson, construction site, occupation health, health management, health management, study, knowledge, and construction project. In the context of research, the construction industry cluster consists of 10 variables including policy, work, safety culture, barriers, design, analysis, cases, construction, safety culture, and case studies.

In fact, pandemic conditions affect various sectors; the number of workers in the process of working on construction projects slows down the progress of construction industry projects in order to suppress the transmission of Covid 19. After efforts are made to minimize occupational health and safety, the control process must still be carried out by making daily reports. Based on the daily reports of the project, it can be evaluated and improved for occupational health and safety management [62].

#### 4. RECOMMENDATION

The recommendations provided have been developed to reduce the impact of Covid-19 on the construction industry. The construction sector as a labor-intensive sector is also an important sector in economic growth and supports the growth of the country's gross domestic product. Disturbances that occur in the construction sector are highly avoided by many countries because they will accelerate the transformation of a state of stagnation into a state of total depression. Therefore, there needs to be fundamental policies developed to help the construction sector rise and overcome the pandemic period while maintaining the integrity of the relationship between companies in this industry, customers, lenders, suppliers and end users. The study found that even if the spread of the virus is contained in the short term, the suffering of construction companies from this pandemic will continue over the coming months until construction activities return to normal, both in terms of effects on project contracts and disruptions in the supply chain.

#### 5. CONCLUSIONS

This research was conducted to pioneer other similar research in the construction sector and provide an overview of the importance of the impact of Covid-19 in the construction industry, which has high costs and absorbs a large workforce. Through a similar case approach in previous studies, researchers found that there was a similarity in the impact of Covid-19 between the strength of risk and environmental factors in their impact on construction projects. Since no specific research was found on the impact of Covid-19 in the countries determined at the beginning of this study, the researchers focused on government reports issued in this regard and then compiled the most critical points that affect the impact of Covid-19 in the construction industry for consideration. In order to reach the essence of the problem, a systematic literature review is needed, and adapted in this research. The Scopus database constraint is the focus of this research. In addition, to support the existing database, the researchers also used government reports from the WHO due to the lack of similar research data. The most important studies linking risk to the impact of Covid-19 on the construction industry are combined in the data in a single table, and the results achieved by the researchers are compared. Therefore, the impact of work safety practices that occurred during the pandemic include: maintaining physical and social distance between workers, one worker doing one job, supervision using innovative technology, and spraying disinfectant on work equipment after finishing work

#### References

- [1] S. V, A. NM, and D. LA, "Risk-based management of occupational safety and health in the construction industry – part 1: background knowledge," *Saf. Sci.*, no. 66, pp. 75–86, 2014.
- [2] T. A, "Towards a better modelling and assessment of construction risk: Insights from a literature review," *Int. J. Proj. Manag.*, no. 32, pp. 101–115, 2014.
- [3] Y. FQ, "Teaching reform of construction safety course," *China Met. Educ.*, no. 06, pp. 12–15, 2016.
- [4] A. AL, R. JCR, and G. A, "Analysis of construction accidents in Spain, 2003–2008," *J. Safety Res.*, no. 43, pp. 381–388, 2012.

- [5] L. Z, T. W, D. CF, Z. L, H. FKP, and Y. R, "Qualitative analysis of the occupational health and safety performance of Chinese international construction projects," *Sustainability*, 2018.
- [6] T. SS, U. DV, and T. NV, "Professional risks in construction industry," 2017.
- [7] T. A and B. A, "Assessment of occupational health and safety performance evaluation tools: state of the art and challenges for small and medium-sized enterprises," *Saf. Sci.*, no. 101, pp. 260–7, 2018.
- [8] H. Liang, W. Yang, T. Liu, and F. Xia, "Demographic Influences on Perceived Stressors of Construction Workers during the COVID-19 Pandemic," *Int. J. Environ. Res. Public Health*, vol. 19, no. 7, 2022, doi: 10.3390/ijerph19074192.
- [9] M. T. Lakhari, M. T. Lakhari, and A. Halid, "High-Rise Building Projects in Pakistan: a Systematic Literature Review," *Res. Eng. Sci.*, vol. 4, no. 1, pp. 99–114, 2021.
- [10] A. Amin and R. I. Gilbert, "Steel Fiber-Reinforced Concrete Beams--Part I: Material Characterization and In-Service Behavior.," *ACI Struct. J.*, 2019, [Online]. Available: <http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08893241&AN=135048485&h=mUXEXyYeys1%2FIGghCnqtoUpv1akdIO%2F3g%2BtPQjon4Nqp6I2RzORddgVh2Da%2FZC7RnPTWv3AnacvVanBYEn2O5g%3D%3D&crl=c>.
- [11] A. Muflihah Darwis, M. Furqaan Nai'em, Y. Thamrin, Noviponiharwani, S. Rahmadani, and F. Amin, "Safety risk assessment in construction projects at Hasanuddin University," *Gac. Sanit.*, vol. 35, pp. S385–S387, 2021, doi: 10.1016/j.gaceta.2021.10.057.
- [12] A. Lamba, "Stakeholder analysis Occupational Safety and Health (OSH) management system," *Journal of Physics: Conference Series*, vol. 1360, no. 1. 2019, doi: 10.1088/1742-6596/1360/1/012024.
- [13] C. MJ, "Does the COVID-19 outbreak mark the onset of a sustainable consumption transition?," *Sustain. Sci. Pract. Policy*, vol. 16, no. 1, pp. 1–3, 2020.
- [14] Q. He, J. Liu, S. Wang, and J. Yu, "The impact of COVID-19 on stock markets," *Econ. Polit. Stud.*, 2020.
- [15] R. J. Zwanka and C. Buff, "COVID-19 generation: a conceptual framework of the consumer behavioral shifts to be caused by the COVID-19 pandemic," *J. Int. Consum. Mark.*, 2020.
- [16] D. S et al., "Risk perceptions of COVID-19 around the world," *J. Risk Res.*, 2020.
- [17] W. Choi, S. J. Lee, W. J. Lee, E. M. Beak, and K. Y. Kim, "Job Satisfaction Level of Safety and Health Manager in Construction Industry: Pandemic Period," *Int. J. Environ. Res. Public Health*, vol. 19, no. 10, 2022, doi: 10.3390/ijerph19105858.
- [18] M. Czeisler et al., "Mental health, substance use, and suicidal ideation during a prolonged COVID-19-related lockdown in a region with low SARS-CoV-2 prevalence," *J. Psychiatr. Res.*, vol. 140, no. January, pp. 533–544, 2021, doi: 10.1016/j.jpsychires.2021.05.080.
- [19] K. Nowacki, S. Grabowska, and K. Łakomy, "Activities of employers and OHS services during the developing COVID-19 epidemic in Poland," *Saf. Sci.*, vol. 131, no. July, 2020, doi: 10.1016/j.ssci.2020.104935.
- [20] J. M. Newby, K. O'Moore, S. Tang, H. Christensen, and K. Faasse, "Acute mental health responses during the COVID-19 pandemic in Australia," *PLoS One*, 2020.
- [21] K. M. Kniffin et al., "COVID-19 and the workplace: Implications, issues, and insights for future research and action.," *Am. Psychol.*, vol. 76, no. 1, pp. 63–77, 2021, doi: 10.1037/amp0000716.
- [22] G. Widyarini, W. G. Pamungkas, and Y. I. Pratiwi, "PEMILIHAN MODA TRANSPORTASI RUAS JALAN PEMUDA KOTA SEMARANG DENGAN METODE PROMETHEE SAAT PANDEMI COVID-19," *Teknika*, vol. 17, no. 1, pp. 12–20, 2022.

- [23] Y. Zheming and C. Yuan, “A simple model to assess Wuhan lock-down effect and region efforts during COVID-19 epidemic in China Mainland,” *medRxiv*, no. March, p. 2020.02.29.20029561, 2020, doi: 10.1101/2020.02.29.20029561.
- [24] S. Brown and L. Claeys, “Six Steps Construction Companies Can Take to Ride Out the Coronavirus Shock,” *Assoc. Gen. Contract. Am.*, 2020.
- [25] M. O. Alfadil, M. A. Kassem, K. N. Ali, and W. Alaghbari, “Construction Industry from Perspective of Force Majeure and Environmental Risk Compared to the COVID-19 Outbreak: A Systematic Literature Review,” *Sustain.*, vol. 14, no. 3, 2022, doi: 10.3390/su14031135.
- [26] D. Koh, “Occupational risks for COVID-19 infection,” *Occup. Med. (Chic. Ill.)*, vol. 70, no. 1, pp. 3–5, 2020, doi: 10.1093/occmed/kqaa036.
- [27] E. S. McClure, P. Vasudevan, Z. Bailey, S. Patel, and W. R. Robinson, “Racial capitalism within public health-how occupational settings drive covid-19 disparities,” *Am. J. Epidemiol.*, vol. 189, no. 11, pp. 1244–1253, 2020, doi: 10.1093/aje/kwaa126.
- [28] A. Alsharif, S. Banerjee, S. M. J. Uddin, A. Albert, and E. Jaselskis, “Early impacts of the COVID-19 pandemic on the United States construction industry,” *Int. J. Environ. Res. Public Health*, vol. 18, no. 4, pp. 1–21, 2021, doi: 10.3390/ijerph18041559.
- [29] O. of N. Statistics., “Causes of death: Coronavirus (COVID- 19) related deaths by occupation, England and Wales: Deaths registered between 9 March and 25 May 2020,” 2020.
- [30] I. L. Organization, “ILO Monitor: COVID-19 and the World of Work,” 2020. [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/briefingnote/wcms\\_740877.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/briefingnote/wcms_740877.pdf).
- [31] G. C. P. O. Economics, “Global Construction 2030: A Global Forecast for the Construction Industry to 2030,” 2015. .
- [32] R. F. Pasco, S. J. Fox, S. C. Johnston, M. Pignone, and L. A. Meyers, “Estimated Association of Construction Work with Risks of COVID-19 Infection and Hospitalization in Texas,” *JAMA Netw. Open*, vol. 3, no. 10, pp. 1–11, 2020, doi: 10.1001/jamanetworkopen.2020.26373.
- [33] M. D. of H. and H. Services, “Coronavirus Outbreak Reporting,” 2022. .
- [34] W. S. D. of Health, “Statewide COVID-19 Outbreak Report,” 2022. <https://www.doh.wa.gov/Portals/1/Documents/1600/coronavirus/data-tables/StatewideCOVID-19OutbreakReport.pdf> (accessed Jul. 10, 2022).
- [35] D. P. Bui et al., “Racial and Ethnic Disparities Among COVID-19 Cases in Workplace Outbreaks by Industry Sector — Utah, March 6–June 5, 2020,” *MMWR. Morb. Mortal. Wkly. Rep.*, vol. 69, no. 33, pp. 1133–1138, 2020, doi: 10.15585/mmwr.mm6933e3.
- [36] A. Pamidimukkala, “Impact of Covid-19 on field and office workforce in construction industry,” *Project Leadership and Society*, vol. 2. 2021, doi: 10.1016/j.plas.2021.100018.
- [37] F. Araya, “Modeling the spread of COVID-19 on construction workers: An agent-based approach,” *Saf. Sci.*, vol. 133, no. September 2020, p. 105022, 2021, doi: 10.1016/j.ssci.2020.105022.
- [38] G. A. Peñalozaa, T. A. Saurin, and T. F. Carlos, “Monitoring complexity and resilience in construction projects: the contribution of safety performance measurement systems,” *Appl. Ergon.*, vol. 82, 2020.
- [39] M. Woolley, G. Natassia, P. Salmon, and G. Read, “Who is responsible for construction safety in Australia? A STAMP analysis,” *Saf. Sci.*, vol. 132, 2020.
- [40] H. F. van der Molen et al., “Interventions to prevent injuries in construction workers,” *Cochrane Database Syst. Rev.*, vol. 2018, no. 2, 2018, doi: 10.1002/14651858.CD006251.pub4.

- [41] S. Stiles, B. Ryan, and D. Golightly, "Evaluating attitudes to safety leadership within rail construction projects," *Saf. Sci.*, vol. 110, 2018.
- [42] H. Lingard, R. Peihua Zhang, C. Räisänen, Y. Miang Goh, P. Bowen, and S. Bhandari, "Special issue: what have we learnt from the COVID-19 global pandemic: improving the construction industry's abilities to foresee, respond to and recover from future endemic catastrophes," *Constr. Manag. Econ.*, vol. 39, no. 2, pp. 192–197, 2021, doi: 10.1080/01446193.2020.1869480.
- [43] S. Stiles, D. Golightly, and B. Ryan, "Impact of COVID-19 on health and safety in the construction sector," *Hum. Factors Ergon. Manuf.*, vol. 31, no. 4, pp. 425–437, 2021, doi: 10.1002/hfm.20882.
- [44] R. R. Elizalde, "COVID-19 in the Construction Sector," *Encyclopedia*, vol. 2, no. 2, pp. 717–728, 2022, doi: 10.3390/encyclopedia2020050.
- [45] R. U. Farooqui, "An exploratory study probing into the factors causing safety non-performance in the Pakistani construction industry," in *45th Institute of Engineers Convention*, 2012, pp. 1–12.
- [46] W. Jones, A. G. F. Gibb, and V. Chow, "Adapting to COVID-19 on construction sites: what are the lessons for long-term improvements in safety and worker effectiveness?," *J. Eng. Des. Technol.*, vol. 20, no. 1, pp. 66–85, Jan. 2022, doi: 10.1108/JEDT-11-2020-0473.
- [47] R. Choudhari, "COVID 19 pandemic: Mental health challenges of internal migrant workers of India," *Asian J. Psychiatr.*, 2020.
- [48] OSHA, "COVID- 19—Control and prevention/construction work," 2020. <https://www.osha.gov/SLTC/covid-19/construction.html>.
- [49] K. Agyekum, "The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms," *J. Eng. Des. Technol.*, vol. 20, no. 1, pp. 222–244, 2022, doi: 10.1108/JEDT-11-2020-0476.
- [50] F. Simpeh, E. Bamfo-Agyei, and C. Amoah, "Barriers to the implementation of COVID-19 safety regulations: insight from Ghanaian construction sites," *J. Eng. Des. Technol.*, vol. 20, no. 1, pp. 47–65, Jan. 2022, doi: 10.1108/JEDT-03-2021-0153.
- [51] C. Amoah and F. Simpeh, "Implementation challenges of COVID-19 safety measures at construction sites in South Africa," *J. Facil. Manag.*, vol. 19, no. 1, pp. 111–128, Jan. 2021, doi: 10.1108/JFM-08-2020-0061.
- [52] I. Moreno-Sueskun et al., "[Return to work in the context of the COVID-19 pandemic in the industrial and construction sectors in Navarre (Spain)].," *Arch. Prev. Riesgos Labor.*, vol. 23, no. 4, pp. 443–457, Oct. 2020, doi: 10.12961/aprl.2020.23.04.04.
- [53] J. Jeon, "Impact of COVID-19 on the US Construction Industry as Revealed in the Purdue Index for Construction," *J. Manag. Eng.*, vol. 38, no. 1, 2022, doi: 10.1061/(ASCE)ME.1943-5479.0000995.
- [54] F. Araya and L. Sierra, "Influence between COVID-19 impacts and project stakeholders in Chilean construction projects," *Sustain.*, vol. 13, no. 18, 2021, doi: 10.3390/su131810082.
- [55] M. Ayat, Malikah, and C. W. Kang, "Effects of the COVID-19 pandemic on the construction sector: a systemized review," *Eng. Constr. Archit. Manag.*, vol. ahead-of-p, no. ahead-of-print, Jan. 2021, doi: 10.1108/ECAM-08-2021-0704.
- [56] M. Ogunnusi, "Lessons learned from the impact of COVID-19 on the global construction industry," *J. Eng. Des. Technol.*, vol. 20, no. 1, pp. 299–320, 2021, doi: 10.1108/JEDT-05-2021-0286.
- [57] A. M. Essa, H. Abid, and J. K. Neeraj, "Delays and Financial Implications of COVID-19 for Contractors in Irrigation Projects," *J. Constr. Eng. Manag.*, vol. 148, no. 9, p. 5022006, Sep. 2022, doi: 10.1061/(ASCE)CO.1943-7862.0002329.
- [58] N. Yusof and M. Iranmanesh, "The Impacts of Environmental Practice Characteristics on Its Implementation

- in Construction Project,” *Procedia Environ. Sci.*, vol. 37, pp. 549–555, 2017, doi: <https://doi.org/10.1016/j.proenv.2017.03.040>.
- [59] Y. J. Huang, J. Tao, F. Q. Yang, and C. Chen, “Construction safety during pandemics: Learning from the xinjia express hotel collapse during covid-19 in china,” *Int. J. Environ. Res. Public Health*, vol. 18, no. 21, 2021, doi: 10.3390/ijerph182111498.
- [60] F. Lestari et al., “COVID-19 in the Workplace in Indonesia,” *Sustain.*, vol. 14, no. 5, pp. 1–24, 2022, doi: 10.3390/su14052745.
- [61] C. Nnaji, Z. Jin, and A. Karakhan, “Safety and health management response to COVID-19 in the construction industry: A perspective of fieldworkers,” *Process Saf. Environ. Prot.*, vol. 159, pp. 477–488, 2022, doi: 10.1016/j.psep.2022.01.002.
- [62] K. Evangelinos et al., “Occupational health and safety disclosures in sustainability reports: An overview of trends among corporate leaders,” *Corp. Soc. Responsib. Environ. Manag.*, vol. 25, no. 5, pp. 961–970, 2018, doi: 10.1002/csr.1512.