

# COVID-19 pandemic impact on occupational health and safety in construction projects: evidence from Jakarta

Putri Fatimah, Ahyahudin Sodri, Udi Syahnoedi Hamzah

Faculty of Environmental Science, Universitas Indonesia, Central Jakarta, Indonesia

## Article Info

### Article history:

Received Apr 5, 2023

Revised Aug 24, 2023

Accepted Sep 19, 2023

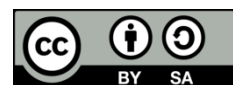
### Keywords:

Construction industry  
COVID-19 impacts  
Indonesia  
Occupational health  
Safety

## ABSTRACT

The construction industry is commonly perceived as high-risk and involves a large workforce. The COVID-19 poses an additional risk in construction projects to occupational health and safety. DKI Jakarta Province is the epicenter of confirmed COVID-19 cases in Indonesia. This research examined the COVID-19 impact on occupational health and safety in construction projects. A quantitative approach was used, an online distribution questionnaire was conducted to construction workers in DKI Jakarta, with 74 workers participating, and the correlation analysis was using the software IBM SPSS. The result shows that the COVID-19 pandemic increases the risk of occupational health and safety and workers' anxiety. However, it has had an indirect positive impact on workers' behavior. Increasing workers' awareness of occupational health, safety, and healthy lifestyles. The findings of this research provide evidence that the COVID-19 pandemic is a driving force for workers' behavior changes and raises awareness of workplace safety and health concerns regarding construction projects.

This is an open access article under the [CC BY-SA](#) license.



## Corresponding Author:

Ahyahudin Sodri

Faculty of Environmental Science, Universitas Indonesia

Salemba Raya Street No.4, 10430 Central Jakarta, Indonesia

Email: ahyahudin.sodri@ui.ac.id

## 1. INTRODUCTION

The construction sector has an essential role in society's employment [1]. However, the construction industry is one of the industries with a high work accident rate [2]. Occupational health and safety are the prevention of occupational diseases and injury, also the protection and promotion of workers' health to improve the working environment [3]. The COVID-19 outbreak is a pandemic reported by the World Health Organization (WHO) on March 11, 2020, that globally affected several countries, including Indonesia [4]. The construction industry has been well known as one of the high-stress industries, and the COVID-19 pandemic brings this pressure to an even higher level [5]. The construction sector is one of the essential sectors and is allowed to operate during the restrictions of community activities, but construction operations must implement strict health protocols. The potential variants virus led to conditions of uncertainty, and COVID-19 poses a significant health and safety risk to construction workers [6]. Construction areas and intensive human contact potentially spread disease, and construction workers are at a higher risk of being exposed to the virus [7].

The COVID-19 pandemic has been occurring for more than three years. The COVID-19 outbreak leads to social distancing, and new health protocols should be strictly enforced. The significant impact of the COVID-19 pandemic occurs in all aspects of daily lifestyles and economic activities, including construction projects [8], [9]. The COVID-19 outbreak is affecting the construction industry, and raising the complexity of workers' health, safety, and well-being [10]. The safety and health of construction workers and the workplace is a major priority to mitigate the spread of COVID-19, but it also requires worker engagement [11].

Furthermore, unsafe workplaces expose workers to viruses, and the unavailability of tools and equipment makes it difficult for workers and potentially leads to mental health issues [10]. Workers frequently work collaboratively in a location with a physical limitation, and some projects require activities performed chiefly indoors or in an enclosed area, especially in the project's final phases when it comes to repairs [12]. In previous research by Olanrewaju *et al.* [6] the COVID-19 effects on the Malaysian construction industry, the crisis caused by the COVID-19 pandemic has led to decreased project productivity, project delays, increased risk for construction workers, and threats to occupational health and safety. Another research mentioned that the COVID-19 pandemic had impacted construction operations, such as delays in projects, supply chain issues, difficulties in workers' management, and health and safety issues [9].

The total number of confirmed cases in Indonesia from January 3<sup>rd</sup>, 2020, until June 14<sup>th</sup>, 2023, is 6,810,417 cases with 161,830 deaths [13]. Several previous studies examined Indonesia's construction sector during the COVID-19 outbreak. Research by Syaferi *et al.* [14] analyzed internal and external factors affecting contractor performance in West Sumatra Province during the COVID-19 pandemic. Research by Oey and Lim [15] identified the challenges faced by the construction industry in terms of expenses, schedule, and performance. Another investigates the impact of the COVID-19 pandemic on Indonesian construction projects during the pre-construction and construction stages [16]. Research by Larasati *et al.* [17] investigated how COVID-19 affects the construction industry, especially in contract implementation. Shima *et al.* [18] examined COVID-19 health protocol standards in Indonesian construction projects. Although several previous research has discussed the COVID-19 impacts on construction projects in Indonesia, research from the construction workers' perspective is notably lacking in terms of occupational health on construction projects during the COVID-19 pandemic. This research aims to examine the impact of the COVID-19 pandemic on occupational health and safety in construction projects in Indonesia based on workers' perspectives, with evidence from Jakarta. This research focuses on construction projects in Jakarta, considering it is the province with the highest number of COVID-19 confirmed cases.

## 2. RESEARCH METHOD

This research was conducted at a private construction company (PT TBP) with more than 50 years of expertise in the field. The population in this research are workers in a private construction company with a project located in DKI Jakarta. The survey respondent (data collection clearance from School of Environmental Science, Universitas Indonesia No S-0025/UN2.F13.D1/PDP.04.02/2021) criteria are construction project workers in DKI Jakarta who worked during the COVID-19 pandemic. Sampling with a simple random technique and minimal sample size determined by using the Isaac and Michael formula [19], as in (1):

$$s = \frac{\chi^2 \times N \times P \times Q}{d^2 (N-1) + \chi^2 \times P \times Q} \quad (1)$$

descriptions:

s = number of samples

$\chi^2$  = Chi-square, the value depends on the degree of freedom and error degree. Degree of freedom 1 and 5% error, Chi-square is 3.841

N = population

P = chance of being correct (0.5)

Q = chance of being wrong (0.5)

D = gap between a sample mean and population mean (0.01; 0.05; and 0.10)

The minimal number of samples based on the calculation result using the Isaac Michael formula (5% bias and error degree) is 71 workers. However, the survey's actual participants were 74 workers. A questionnaire survey for collecting quantitative data uses a Likert 5-point scale, rating from 1 for strongly disagree to 5 for strongly agree. The Likert scale was developed to measure attitudes, the typical Likert scale is a 5- or 7-point ordinal scale that is used by respondents to indicate their level of agreement or disagreement with a statement [20]. A 5-point scale provides greater data quality compared to seven response categories [21]. The optimal number of alternative responses is 5 scales [22]. Distribution questionnaire using an online survey from September 2022 until October 2022.

The purpose of the pre-test of the research instrument is to identify ambiguities and misunderstandings, and 30 participants are the required minimum sample [23]. The research instruments have been pre-tested by 37 construction workers. The instrument validity test was obtained by Pearson's coefficient and the result of Pearson's coefficient of 0.471 to 0.872. Interpreting Pearson's coefficient if the value is more than 0.35 means highly valid [24]. Validity examines the strength of the research design, with high validity leading to meaningful

results [20]. Reliability tests based on Cronbach's alpha value, an acceptable value of 0.7 or 0.6 [25], and the range of 0.60-0.80 are categorized as moderately acceptable [26]. The Cronbach's Alpha result is 0.674, which is acceptable reliability. IBM SPSS statistics version 28 was applied to analyze descriptive statistics and bivariate correlation. The correlation coefficient varies from -1 and +1, where zero means there is no correlation, and 1 means there is perfect correlation [27]. The interpretation of the correlation coefficient is a strong correlation (0.7-0.9), moderate correlation (0.4-0.6), and weak correlation (0.1-0.3) [28].

### 3. RESULTS AND DISCUSSION

#### 3.1. Profile of respondents

The total number of construction workers involved as respondents were 74 workers. Demographic characteristics of respondents according to gender, education, job position, and work experience in the construction industry. Respondents' demographic characteristics are shown in Table 1.

Table 1. Profile of respondents (n=74)

| Characteristic respondents          | Frequency (F) | Percentage (%) |
|-------------------------------------|---------------|----------------|
| Gender                              |               |                |
| Male                                | 74            | 97             |
| Female                              | 2             | 3              |
| Education                           |               |                |
| Senior high school or equal         | 21            | 28             |
| Associate degree (D3)               | 8             | 11             |
| Undergraduate (D4/S1)               | 40            | 54             |
| Graduate (S2)                       | 5             | 7              |
| Job position                        |               |                |
| Site manager                        | 14            | 18.9           |
| HSE                                 | 11            | 14.9           |
| Quality supervisor                  | 11            | 14.9           |
| Engineer                            | 11            | 14.9           |
| Cashier/commercial                  | 8             | 10.8           |
| Drafter                             | 8             | 10.8           |
| Project manager                     | 4             | 5.4            |
| Quantity surveyor                   | 4             | 5.4            |
| General affair                      | 3             | 4.1            |
| Experience in construction industry |               |                |
| More than 3 to 7 years              | 7             | 9.5            |
| More than 7 to 10 years             | 13            | 17.6           |
| More than 10 to 19 years            | 25            | 33.8           |
| 20 years or more                    | 29            | 39.2           |

Respondents have sufficient experience working in construction. This statement is supported by 73% of the participants experienced over ten years in construction projects. Respondents involved in this research from several job positions in the construction project, so the survey represents the perceptions of construction workers in general.

#### 3.2. Distribution of workers' responses

The questionnaire to construction workers analyzed five items, which include awareness of safety and occupational health increased during the COVID-19 pandemic, anxiety increases when working during the COVID-19 pandemic, risks of occupational health and safety on projects are higher during the COVID-19 pandemic, increased clean and healthy lifestyles, and improved occupational health and safety planning during the COVID-19 pandemic. Figure 1 provides the distribution of questionnaire responses. Based on the questionnaire (Figure 1), the workers have responded positively to the statement that during the pandemic, there has been an increase in occupational safety and health awareness, clean and healthy lifestyle, and planning. On the other hand, the negative impact is perceived by workers that anxiety increased when working on the project during the pandemic, also risks to occupational health and safety in construction projects increased due to the pandemic. A major construction project involves several hundred workers, collaborative working is required, and some works are mainly carried out indoors or underground, the COVID-19 pandemic has posed additional risks and challenges in managing health and safety on construction projects [12].

#### 3.3. Occupational health aspects in the construction project during the COVID-19 pandemic

Correlation analysis of data from survey responses of 74 construction workers. The correlation is calculated to determine the relationship between items, as well as the significance relationship. Table 2 shows the result of the correlation analysis.

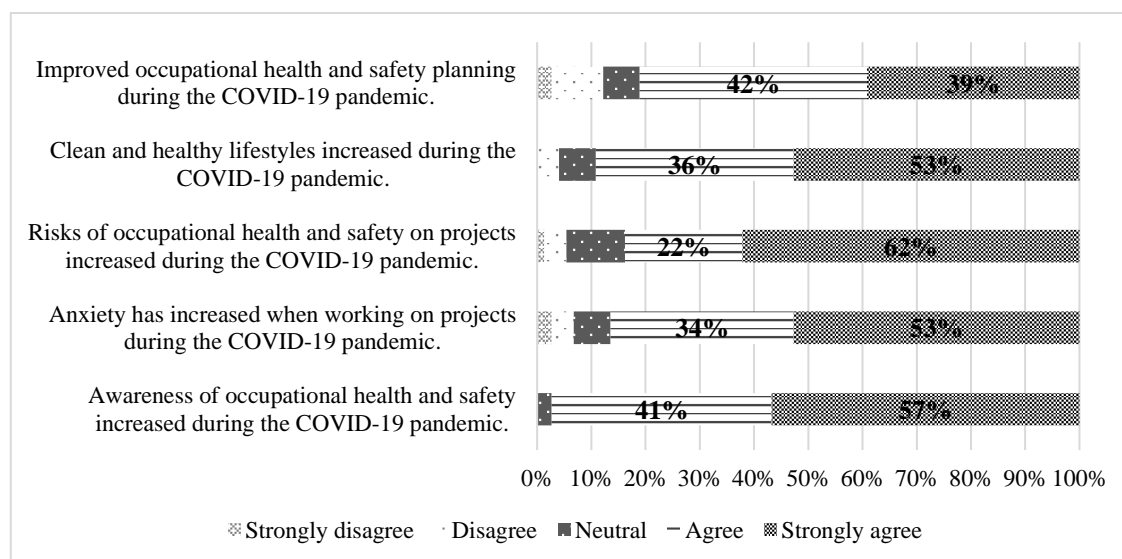


Figure 1. Distribution of workers' responses (n=74)

Table 2. Risk of occupational health and safety correlation analysis

| Aspects   | Correlation coefficient | Sig. (2-tailed) | Result  |
|---|-------------------------|-----------------|---|
| Risks of occupational health and safety on projects increased during the COVID-19 pandemic. | 0.492**                 | <0.001          | Significant and positive moderate correlation |
| Awareness of occupational health and safety increased during the COVID-19 pandemic.         | 0.482**                 | <0.001          | Significant and positive moderate correlation |
| Clean and healthy lifestyles increased during the COVID-19 pandemic.                        | 0.401**                 | <0.001          | Significant and positive moderate correlation |
| Improved occupational health and safety planning during a pandemic.                         | 0.346**                 | <0.001          | Significant and positive weak correlation     |

\*\*Correlation is significant at the 0.01 level (2-tailed)

Based on the correlation analysis, the highest coefficient value is 0.492, indicating a moderately strong positive relationship between occupational health and safety risks and increased worker anxiety during the COVID-19 pandemic. A positive relationship means the increased risk of occupational health and safety during the pandemic also triggered increased worker anxiety while working on construction projects. The result of this research is in line with the previous research according to Liang *et al.* [5] due to the threat of COVID-19 along with other health effects, including high mortality rates, the COVID-19 pandemic has significant effects on psychological, fear, and anxiety of workers. The stigma and anxiety of COVID-19 has been felt by citizens of the general Indonesian population [29]. Symptoms of anxiety and depression have increased significantly during the COVID-19 pandemic, and construction workers are already struggling due to the COVID-19 pandemic [30]. Supported by the previous research, the impact of the pandemic on construction workers found that workers who experienced high levels of fear of COVID-19 and job insecurity had higher levels of psychological distress [5].

The construction work and its activities pose a risk of infectious disease transmission if occupational health actions are not taken [31]. In normal conditions before the COVID-19 pandemic, construction work was at high risk to workers' occupational health and safety. The pandemic preparedness was not a priority for the construction sector, mainly focused on physical hazards such as falls from height, vehicle incidents, and heat injuries [31]. Different from the findings of the studies of pre-pandemic COVID-19, this research provides evidence that the COVID-19 pandemic is a driver of changes in workers' behavior occupational health and safety aspects, also occupational health and safety aspects are prioritized. Project managers should increase worker involvement in project activities to reduce the spread of COVID-19, in addition to proactive ways to cope with uncertain situations [11].

However, besides the increased risk of occupational health and safety, and worker anxiety, it positively impacts workers' awareness of occupational health and safety, also improving occupational health and safety planning in construction projects. Risks of occupational health and safety also had a positive relationship with awareness of occupational health and safety (correlation coefficient is 0.482; moderate

relationship), clean and healthy lifestyles (correlation coefficient is 0.401; moderate relationship), and improved occupational health and safety planning during pandemic (correlation coefficient is 0.346; weak relationship). These results reveal that the COVID-19 pandemic and the implementation of health protocols due to COVID-19 workers' adaptation to COVID-19 have led workers to adapt and change their behavior in terms of occupational health and safety. Previous research conducted among Thailand construction workers [32] also found that workers' perceived severity and exposures has a significant direct influence on behavioral control, for example, the attitude to adopt preventive safety practices.

Furthermore, a correlation test was conducted to analysis the positive impact on workers' awareness of occupational health and safety. Table 3 shows a positive correlation with a moderate relationship between awareness of occupational health and safety, with a clean and healthy lifestyle during the COVID-19 pandemic. Moreover, a positive correlation exists between awareness of occupational health and safety, with improved occupational health and safety planning during a pandemic. Workers' anxiety due to the COVID-19 pandemic has also led to increased awareness of occupational health and safety, also occupational health and safety planning for operational construction projects during a pandemic. Workers' self-responsibility seeks more awareness of their movement on site and adopt a personal hygiene routine to stay safe [33].

Table 3. Awareness of occupational health and safety, and anxiety correlation analysis

| Aspects   |   | Correlation coefficient | Sig. (2-tailed) | Result  |
|---|---|-------------------------|-----------------|---|
| Awareness of occupational health and safety increased during the COVID-19 pandemic. | Clean and healthy lifestyles increase during the COVID-19 pandemic.                 | 0.401**                 | <0.001          | Significant and positive moderate correlation |
|   | Improved occupational health and safety planning during a pandemic.                 | 0.334**                 | 0.002           | Significant and positive weak correlation     |
| Increased workers' anxiety during work during the COVID-19 pandemic                 | Awareness of occupational health and safety increased during the COVID-19 pandemic. | 0.354**                 | 0.001           | Significant and positive weak correlation     |
|   | Improved occupational health and safety planning during a pandemic.                 | 0.253*                  | 0.015           | Significant and positive weak correlation     |

\*\*Correlation is significant at the 0.01 level (2-tailed)

\*Correlation is significant at the 0.05 level (2-tailed)

The project team is more concerned about occupational health and safety during a pandemic, hence occupational health and safety planning has been prioritized. In line with research Ko and Abdulmajeed [34] the impact of COVID-19 on the construction industry identified positive impacts such as significantly improving the safety, hygiene, and cleanliness of the working environment, safety work methods, and response to health and safety changes also increased. Based on the questionnaire responses, almost all construction workers practiced clean and healthy lifestyles during the COVID-19 pandemic. The impact of COVID-19 has led to new lifestyles, and unexpected conditions during the pandemic force us to be able to survive this pandemic [35]. Occupational health and safety are important and were prioritized during the COVID-19 pandemic. Almost all construction workers stated increased occupational health and safety awareness during the COVID-19 pandemic. While worker behavior is changing in a positive practice, the COVID-19 pandemic is having a negative impact on construction workers as well.

Workers' health and safety behavior is improved due to the pressure of the COVID-19 pandemic, not only essential during the COVID-19 pandemic, but it also needs to be continued since the construction project has a high risk to occupational health and safety. In crisis conditions such as the COVID-19 pandemic or another potentially unknown crisis in the future, planning and improvement are essential in providing a safe and healthy workplace, as well as caring for the health workers both physically and psychologically. Companies and project management are required to implement programs to maintain and increase the workers' awareness of occupational health and safety. In line with the result of other research examining construction workers in Thailand, planned behavior, protection motivation, and preventive behavior of construction workers during the COVID-19 pandemic [32]. The COVID-19 pandemic's effects on safety in construction depend on the policy and management structure, research by Duan *et al.* [36] comparing the effects in the United States, and China. Supported by Kassem *et al.* [37] research result, the pandemic had a major impact on the workforce and workplace, changes in the work environment, and increasing organizational concern.

The COVID-19 outbreak is an additional risk in operational construction projects which is a high-risk work, but also an opportunity for momentum to improve the occupational health and safety management system. The limitation of this research, the survey was conducted on construction workers from a private company as the main contractor, suggestions for future research is to survey of subcontractor's workers. Although these limitations, the findings of this research contribute evidence for the existence of the COVID-19 pandemic on occupational health aspects of construction projects based on the perceptions of the workers.

#### 4. CONCLUSION

Despite the negative impact of the COVID-19 pandemic, there seems to be a positive side that construction workers are more aware of occupational health and safety, as well as changes in health behavior. The occurrence of COVID-19 is an experience for construction workers to adapt and realize the importance of occupational health and safety. Therefore, the recommendation is to investigate the behavior of construction workers in the post-pandemic period, whether they still care about occupational health and safety, and persist in clean and healthy habits such as health protocol during the pandemic. Strategies and preparedness must be developed to ensure resilience in the post-pandemic era, also unpredictable risks or other pandemics in the future. Occupational health and health in construction projects is not limited to accident prevention but also pays attention to the psychology and well-being of workers.

#### ACKNOWLEDGEMENTS

This research was financially supported by the School of Environmental Science, Universitas Indonesia, under contract number PKS-0094/UN2.F13.D1/PPM.00.00/2021. The authors would like to thank the construction company (PT TBP) for granting permission and the employees who participated in this research.





#### REFERENCES

- [1] Z.-J. Liu, P. Pyplacz, M. Ermakova, and P. Konev, "Sustainable construction as a competitive advantage," *Sustainability*, vol. 12, no. 15, pp. 1–13, Jul. 2020, doi: 10.3390/su12155946.
- [2] International Labour Organization, "World Statistic," *Occupational Safety and Health*, 2020. [https://www.ilo.org/moscow/areas-of-work/occupational-safety-and-health/WCMS\\_249278/lang-en/index.htm](https://www.ilo.org/moscow/areas-of-work/occupational-safety-and-health/WCMS_249278/lang-en/index.htm) (accessed Mar. 25, 2021).
- [3] E. Beres, "Technical and ethical guidelines for workers' health surveillance," *International Labour Organization*. Geneva, 1998.
- [4] World Health Organization, "Novel coronavirus (2019-nCoV): situation report, 22," *World Health Organization*. pp. 1–7, 2020.
- [5] H. Liang, T. Liu, W. Yang, and F. Xia, "Impact of COVID-19 Pandemic Perception on Job Stress of Construction Workers," *International journal of environmental research and public health*, vol. 19, no. 16, 2022, doi: 10.3390/ijerph191610169.
- [6] A. Olanrewaju, A. AbdulAziz, C. N. Preece, and K. Shobowale, "Evaluation of measures to prevent the spread of COVID-19 on the construction sites," *Cleaner Engineering and Technology*, vol. 5, no. 100277, 2021, doi: 10.1016/j.clet.2021.100277.
- [7] Z. Li, Y. Jin, W. Li, Q. Meng, and X. Hu, "Impacts of COVID-19 on construction project management: a life cycle perspective," *Engineering, Construction and Architectural Management*, vol. 30, no. 8, pp. 3357–3389, Sep. 2023, doi: 10.1108/ECAM-10-2021-0873.
- [8] Z. Wang, Z. Liu, and J. Liu, "Risk identification and responses of tunnel construction management during the COVID-19 pandemic," *Advances in Civil Engineering*, vol. 2020, no. 6620539, 2020, doi: 10.1155/2020/6620539.
- [9] S. P. Timilsina, S. K. Ojha, and B. R. Dhungana, "Impact of Covid-19 on Construction Industry of Nepal," *Modern Economy*, vol. 12, no. 08, pp. 1232–1244, 2021, doi: 10.4236/me.2021.128064.
- [10] A. Pamidimukkala and S. Kermanshachi, "Impact of COVID-19 on field and office workforce in construction industry," *Project Leadership and Society*, vol. 2, pp. 1–10, Dec. 2021, doi: 10.1016/j.plas.2021.100018.
- [11] S. Hussain, W. Xuetong, T. Hussain, A. H. Khoja, and M. Z. Zia, "Assessing the impact of COVID-19 and safety parameters on energy project performance with an analytical hierarchy process," *Utilities Policy*, vol. 70, pp. 1–8, Jun. 2021, doi: 10.1016/j.jup.2021.101210.
- [12] 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?," *Journal of Engineering, Design and Technology*, vol. 20, no. 1, pp. 66–85, 2022, doi: 10.1108/JEDT-11-2020-0473.
- [13] World Health Organization, "COVID-19 Homepage - Indonesia situation," *WHO Health Emergency Dashboard*, 2023.
- [14] D. O. Syaferi, B. Hidayat, T. Ophiyandi, and R. Ferial, "Analysis of the contractor's performance during the COVID-19 pandemic in West Sumatra Province," in *IOP Conference Series: Earth and Environmental Science*, Apr. 2021, pp. 1–13. doi: 10.1088/1755-1315/708/1/012064.
- [15] E. Oey and J. Lim, "Challenges and action plans in construction sector owing to COVID-19 pandemic – a case in Indonesia real estates," *International Journal of Lean Six Sigma*, 2021, doi: 10.1108/IJLSS-09-2020-0149.
- [16] R. Susanti, S. Fauziyah, and P. U. Pramesti, "Lesson from pandemic Covid-19 for sustainability construction in Indonesia," in *AIP Conference Proceedings*, 2021, pp. 1–6. doi: 10.1063/5.0072599.
- [17] D. Larasati, N. Ekawati, S. Triyadi, A. F. Muchlis, and A. Wardhani, "Impact of the pandemic COVID-19 on the Implementation of construction contracts," *IOP Conference Series: Earth and Environmental Science*, vol. 738, no. 1, 2021, doi: 10.1088/1755-1315/738/1/012075.
- [18] R. D. Shima, I. Mahani, K. S. Pribadi, and K. A. Hartono, "Study of COVID-19 health protocol standards in construction industry of Indonesia," *Journal of Engineering and Technological Sciences*, vol. 54, no. 6, pp. 1229–1244, 2022, doi: 10.5614/j.eng.technol.sci.2022.54.6.10.
- [19] S. Isaac and W. B. Michael, *Handbook in research and evaluation: A collection of principles, methods, and strategies useful in the planning, design, and evaluation of studies in education and the behavioral sciences*, 3rd ed. San Diego, CA, US: EdITS Publishers, 1995.
- [20] G. M. Sullivan and A. R. Artino, "Analyzing and interpreting data from likert-type scales," *Journal of Graduate Medical Education*, vol. 5, no. 4, pp. 541–542, Dec. 2013, doi: 10.4300/jgme-5-4-18.
- [21] M. A. Revilla, W. E. Saris, and J. A. Krosnick, "Choosing the number of categories in agree–disagree scales," *Sociological Methods & Research*, vol. 43, no. 1, pp. 73–97, Feb. 2014, doi: 10.1177/0049124113509605.
- [22] X. Chen, H. Yu, and F. Yu, "What is the optimal number of response alternatives for rating scales? From an information processing perspective," *Journal of Marketing Analytics*, vol. 3, no. 2, pp. 69–78, 2015, doi: 10.1057/jma.2015.4.
- [23] T. V. Perneger, D. S. Courvoisier, P. M. Hudelson, and A. Gayet-Ageron, "Sample size for pre-tests of questionnaires," *Quality of Life Research*, vol. 24, no. 1, pp. 147–151, 2015, doi: 10.1007/s11136-014-0752-2.
- [24] S. Saad, G. W. Carter, M. Rothenberg, and E. Israelson, "Testing and assessment: an employer's guide to good practices," Washington, 1999. <https://files.eric.ed.gov/fulltext/ED447310.pdf> (accessed Mar. 25, 2021).





- [25] R. A. L. F. van Griethuijsen *et al.*, "Global patterns in students' views of science and interest in science," *Research in Science Education*, vol. 45, no. 4, pp. 581–603, 2015, doi: 10.1007/s11165-014-9438-6.
- [26] K. A. M. Daud, N. Z. Khidzir, A. R. Ismail, and F. A. Abdullah, "Validity and reliability of instrument to measure social media skills among small and medium entrepreneurs at Pengkalan Datu River," *International Journal of Development and Sustainability*, vol. 7, no. 3, pp. 1026–1037, 2018.
- [27] L. Gust and X. B. D'journo, "The use of correlation functions in thoracic surgery research," *Journal of Thoracic Disease*, vol. 7, no. 3, pp. E11–E15, 2015, doi: 10.3978/j.issn.2072-1439.2015.01.54.
- [28] H. Akoglu, "User's guide to correlation coefficients," *Turkish Journal of Emergency Medicine*, vol. 18, no. August, pp. 91–93, 2018, doi: 10.1016/j.tjem.2018.08.001.
- [29] E. Umar, A. Darajat, I. Fiddyanti, and L. Amaliah, "Related factors to fear and stigma of COVID-19," *International Journal of Public Health Science (IJPHS)*, vol. 11, no. 3, pp. 1125–1132, Sep. 2022, doi: 10.11591/ijphs.v11i3.21377.
- [30] S. Brown, A. B. Trueblood, W. Harris, and X. S. Dong, "Construction worker mental health during the COVID-19 pandemic," *Centers for Disease Control and Prevention*, 2022.
- [31] W. H. Gan and D. Koh, "COVID-19 and return-to-work for the construction sector: lessons From Singapore," *Safety and Health at Work*, vol. 12, no. 2, pp. 277–281, 2021, doi: 10.1016/j.shaw.2021.04.001.
- [32] S. Khaday, K.-W. Li, and H. Dorloh, "Factors affecting preventive behaviors for safety and health at work during the COVID-19 pandemic among Thai construction workers," *Healthcare*, vol. 11, no. 3, pp. 1–20, Feb. 2023, doi: 10.3390/healthcare11030426.
- [33] F. A. Ghansah and W. Lu, "Responses to the COVID-19 pandemic in the construction industry: a literature review of academic research," *Construction Management and Economics*, vol. 41, no. 9, pp. 781–803, 2023, doi: 10.1080/01446193.2023.2205159.
- [34] C.-H. Ko and H. A. Abdulmajeed, "Improving construction safety: lessons learned from COVID-19 in the United States," *Sustainability*, vol. 14, no. 12, pp. 1–12, Jun. 2022, doi: 10.3390/su14127137.
- [35] F. Hizra, C. Dewi, and Izziah, "Houses amid COVID-19: environmental challenges and design adaptation," in *IOP Conference Series: Earth and Environmental Science*, Nov. 2021, pp. 1–9, doi: 10.1088/1755-1315/881/1/012033.
- [36] P. Duan, Y. M. Goh, and J. Zhou, "The impact of COVID-19 pandemic on construction safety in China and the US: a comparative study," *Safety Science*, vol. 161, pp. 1–12, May 2023, doi: 10.1016/j.ssci.2023.106076.
- [37] M. A. Kassem, A. R. Radzi, A. Pradeep, M. Algahtany, and R. A. Rahman, "Impacts and Response Strategies of the COVID-19 Pandemic on the Construction Industry Using Structural Equation Modeling," *Sustainability*, vol. 15, no. 3, pp. 1–24, 2023, doi: 10.3390/su15032672.

## BIOGRAPHIES OF AUTHORS







**Putri Fatimah**     Magister Environmental Science from the School of Environmental Science, Universitas Indonesia. She got a bachelor's degree from the Environmental Engineering Department, National Institute of Technology, Bandung. She also works as an HSE Officer at a construction company in Jakarta, Indonesia. She can be contacted at email: putri.fatimah@ui.ac.id or putrifatimah027@gmail.com.



**Ahyahudin Sodri**     assistant Professor in the School of Environmental Science, Universitas Indonesia, and Steering Committee at the 3<sup>rd</sup> International Symposium of Earth, Environmental Science and Sustainable Development 2022. He got his Master's degree in Sensory System Technology from FH Karlsruhe Germany and was awarded a Doctoral degree from the School of Environmental Science, Universitas Indonesia. He has published many articles in reputable journals indexed by Scopus. He leads the research cluster of eco-innovation, cleaner production consumption, life cycle assessment, circular economy, and environmental engineering. He can be contacted at email: ahyahudin.sodri@ui.ac.id.



**Udi Syahnoedi Hamzah**     lecturer in the School of Environmental Science, Universitas Indonesia. He currently acts as a supervisory board of the Indonesian Environmental Scientists Association (IESA). He was awarded a Doctoral degree from the School of Environmental Science, Universitas Indonesia. He interested research of waste management, occupational health and safety, and environmental system management. He can be contacted at email: udi.syahnoedi@ui.ac.id.