RUSTIC: Jurnal Arsitektur
Vol. 6, issue No. 2, July - December 2026, pp. 113~119
e-ISSN: 2775-7528, DOI: doi.org/10.32546/rustic.v6i2.3497

Construction Risk Management Under Pandemic Conditions: An Activity-Level Assessment of Construction Activities in Indonesia

Budi Adi Dharma Siregar[1], Mohammad Azhar[2], Pio Ranap Tua Naibaho[3]
[1]Architecture Program, Faculty of Engineering & Design, Institut Teknologi & Bisnis Ahmad Dahlan, Banten, Indonesia
[2-3] Civil Engineering Program, Faculty of Engineering, Universitas Tama Jagakarsa, Jakarta, Indonesia

Article Info

Article history:

Received May 12, 2026
Revised June 30, 2026
Accepted July 1, 2026

Keywords:

Construction activities;
Construction risk management;
COVID-19;
Occupational health and safety;
Project resilience

ABSTRACT

The COVID-19 pandemic significantly disrupted construction projects worldwide by introducing risks related to occupational health and safety (OHS), workforce availability, and material supply. While previous studies have largely focused on project- and organizational-level impacts, limited empirical research has examined how pandemic-related risks affect individual construction activities. This study investigates pandemic-related risks from an activity-level perspective and proposes mitigation strategies based on evidence from a developing-country context. A descriptive quantitative approach was employed using a questionnaire survey of 112 construction practitioners involved in active projects during the pandemic. Data were analyzed using Mean Score Analysis and the Relative Importance Index (RII) to evaluate the severity of risks affecting construction stakeholders and specific construction activities. The results show that OHS was the most critical risk category (mean = 3.82), followed by labor availability (3.71) and material procurement (3.58). At the activity level, masonry work was the most affected (mean = 3.79), followed by earthwork (3.63) and concrete work (3.49). These findings indicate that pandemic-related risks are unevenly distributed across construction activities, with labor-intensive activities being particularly vulnerable to health restrictions and workforce disruptions. This study extends construction risk management literature by introducing an activity-level assessment perspective and emphasizes the need to integrate health-related risks into conventional risk management frameworks while adopting activity-specific mitigation strategies to improve resilience against future public health emergencies and other large-scale disruptions.

Corresponding Author:

Budi Adi Dharma Siregar
Architecture Program, Faculty of Engineering & Design, Institut Teknologi & Bisnis Ahmad Dahlan
Campus A, Jalan Ir. H. Juanda No.77, East Ciputat, South Tangerang, Banten, Indonesia 15419
Email: budi270673@gmail.com

1. INTRODUCTION

The construction industry plays a vital role in economic development by supporting infrastructure provision, generating employment opportunities, and stimulating investment. Despite its significant contribution, construction projects are inherently exposed to numerous uncertainties due to their complexity, dynamic working environments, resource constraints, and the involvement of multiple stakeholders [7] [9]. These uncertainties may adversely affect project performance in terms of cost, schedule, quality, and safety, making effective risk management an essential component of successful project delivery.

The COVID-19 pandemic created an unprecedented global disruption that fundamentally altered construction project execution. Government-imposed mobility restrictions, mandatory health protocols, workforce limitations, and supply chain interruptions significantly affected construction productivity, project

scheduling, and operational efficiency [13] [5]. Unlike conventional construction risks, pandemic-related risks simultaneously impacted multiple aspects of project performance, requiring contractors to address not only technical and financial challenges but also public health concerns. Consequently, occupational health and safety (OHS), labor availability, and material procurement emerged as critical risk factors during the pandemic [2].

Although a growing body of literature has examined the effects of the COVID-19 pandemic on construction projects, most studies have focused on project-level and organizational-level impacts, including schedule delays, productivity losses, cost escalation, and supply chain disruptions [3] [1] [8]. However, empirical evidence remains limited regarding how pandemic-related risks affect individual construction activities. This gap is particularly important in labor-intensive construction environments such as Indonesia, where different activities vary considerably in their dependence on manual labor, worker interaction, equipment, and material availability. As a result, the severity of pandemic-related risks is likely to differ across construction activities.

Therefore, this study investigates pandemic-related risks from an activity-level perspective by assessing the relative impact of major risk categories on selected construction activities. By identifying the activities most vulnerable to pandemic-induced disruptions, this study provides a more granular understanding of construction risk management and offers practical insights for developing activity-specific mitigation strategies to enhance project resilience against future public health emergencies and other large-scale disruptions.

1.1 Construction Risk Management

Construction risk management is a systematic process of identifying, assessing, responding to, and monitoring uncertainties that may influence project objectives, including cost, schedule, quality, safety, and overall project performance [6] [9]. Due to the fragmented nature of the construction industry and the involvement of multiple stakeholders, construction projects are inherently exposed to diverse sources of risk throughout the project lifecycle. These risks originate from technical complexity, financial uncertainty, contractual disputes, regulatory changes, environmental conditions, and social factors [10].

Effective risk management enables project stakeholders to anticipate potential disruptions, allocate resources efficiently, and implement preventive or corrective measures before risks escalate into project failures. Traditional construction risk management frameworks generally categorize risks into internal risks, which are associated with project execution and management, and external risks, which arise from economic, political, environmental, or legal conditions. However, these frameworks have largely been developed under relatively stable operating environments and primarily focus on predictable project uncertainties.

The COVID-19 pandemic exposed a significant limitation of conventional construction risk management practices by demonstrating that large-scale public health emergencies can simultaneously affect multiple dimensions of project performance. Unlike conventional risks that are often localized or project-specific, pandemic-related risks are systemic, dynamic, and highly interconnected, influencing workforce availability, material procurement, project financing, contractual obligations, and occupational safety simultaneously [11]. Consequently, construction risk management frameworks need to evolve by incorporating health-related risks and enhancing project resilience against future large-scale disruptions.

1.2. Occupational Health and Safety Risks During COVID-19

Occupational health and safety (OHS) became one of the most critical concerns for the construction industry during the COVID-19 pandemic. Construction activities typically require close physical interaction among workers, frequent equipment sharing, collaborative teamwork, and continuous movement across dynamic work environments, making construction sites particularly vulnerable to infectious disease transmission [2]. Unlike many office-based industries, construction work cannot be fully performed remotely, increasing workers' exposure to health risks while maintaining project continuity.

To minimize virus transmission, governments and construction authorities introduced various preventive measures, including mandatory use of personal protective equipment (PPE), physical distancing, routine health screening, temperature monitoring, site sanitization, staggered work schedules, and limitations on workforce density. While these measures successfully reduced infection risks, they also altered normal construction operations by reducing labor productivity, increasing operational costs, and creating additional management complexity.

Previous studies consistently reported that COVID-19-related OHS measures negatively affected project performance. Reduced workforce capacity, temporary site closures following confirmed infections, quarantine requirements, and stricter health protocols resulted in schedule delays, increased labor costs, and decreased construction productivity. These findings demonstrate that occupational health risks during a pandemic should no longer be treated solely as safety issues but also as strategic project risks that significantly influence construction performance.

1.3. Pandemic-Induced Risks in Construction Project

Beyond occupational health risks, the COVID-19 pandemic generated a wide range of interconnected risks affecting nearly every aspect of construction project delivery. One of the most significant challenges was labor availability. Government-imposed mobility restrictions, regional lockdowns, quarantine regulations, and workers' health concerns reduced workforce availability and disrupted labor allocation across construction sites. Many projects experienced labor shortages due to travel restrictions affecting migrant workers and limitations on workforce density implemented to comply with health regulations.

The pandemic also severely disrupted global and domestic construction supply chains. Manufacturing slowdowns, transportation restrictions, border closures, and fluctuating market demand contributed to shortages of construction materials and substantial increases in material prices [8]. Delays in material procurement subsequently disrupted project schedules, increased project costs, and reduced overall productivity.

In addition, the pandemic created financial and contractual uncertainties. Project owners experienced budget constraints, contractors faced cash flow problems, and contract execution became increasingly complicated due to force majeure conditions and changing government regulations. These interconnected risks demonstrate that pandemic-related disruptions extend beyond traditional project risks by simultaneously affecting human resources, logistics, financial management, and operational decision-making [3]. Therefore, pandemic-induced risks should be recognized as an integral component of modern construction risk management frameworks.

1.4. Research Gap

Existing literature has extensively examined the impacts of the COVID-19 pandemic on construction projects from project-level and organizational perspectives. Previous studies primarily focused on project delays, cost overruns, workforce productivity, supply chain disruptions, contractual issues, and organizational resilience [1] [3] [8]. These studies have substantially improved understanding of the macro-level consequences of the pandemic on construction project performance.

However, relatively little attention has been given to how pandemic-related risks influence individual construction activities. Construction projects consist of multiple activities with varying levels of labor intensity, equipment dependency, material requirements, and operational characteristics. Consequently, the vulnerability of each activity to pandemic-related disruptions is unlikely to be uniform. Labor-intensive activities requiring close worker interaction, such as masonry or concrete work, may experience greater disruption than equipment-intensive activities.

This knowledge gap is particularly evident in developing countries such as Indonesia, where construction projects often rely heavily on manual labor and face additional challenges related to resource availability and health protocol implementation. Understanding risk at the activity level can provide more precise information for prioritizing mitigation strategies, optimizing resource allocation, and improving project resilience during future public health emergencies. Therefore, this study investigates pandemic-related risks from an activity-level perspective by identifying the most affected construction activities and evaluating the relative importance of different risk categories. This approach complements existing project-level studies and contributes a more granular understanding of construction risk management under pandemic conditions.

2. METHOD

This study used a descriptive quantitative research design to examine risks arising due to the pandemic at the activity level in the construction industry in Indonesia. Questionnaire data was collected by administering it to construction professionals who were working on construction projects amid the coronavirus outbreak.

A total of 112 valid questionnaires was completed by project managers, site engineers, contractors, and site supervisors using the purposive sampling method. These participants had to meet the criteria of at least three years of work experience in construction project management and participation in executing projects under the pandemic condition.

Two parts constituted the structure of the questionnaire: (1) impact of pandemic-related risks on stakeholders and resources of the construction project, and (2) impact of pandemic conditions on specific construction activities. Respondents gave answers based on a four-point Likert scale with options 1 – no impact and 4 – very significant impact.

Questionnaire tool was validated and checked for reliability before analyzing the data. All items in the questionnaire proved their validity with $r > 0.30$ while Cronbach's Alpha score was found equal to 0.846. The collected data were then analyzed with the help of Mean Score Analysis.

3. RESULTS

3.1. Impact of Pandemic-Related Risks on Construction Projects

Table 1. Ranking of Pandemic-Related Risks

Risk factor	Mean Score	Rank
Occupational Health and Safety	3.82	1
Labor Availability	3.71	2
Material Procurement	3.58	3
Equipment Availability	3.22	4
Financial Risk	3.11	5

The results indicate that occupational health and safety (OHS) was perceived as the most significant risk during the COVID-19 pandemic, with the highest mean score of 3.82. This finding reflects the substantial challenges faced by construction projects in maintaining worker safety while ensuring project continuity under strict public health regulations. Construction sites involve frequent physical interaction, shared equipment, and labor-intensive operations, making compliance with health protocols such as physical distancing, routine health screening, mandatory use of personal protective equipment (PPE), and site sanitization particularly challenging. Consequently, OHS risks extended beyond worker protection and directly influenced project productivity, scheduling, and operational efficiency.

The availability of labor ranked as the second most critical risk, with a mean score of 3.71. Workforce shortages were primarily driven by government-imposed mobility restrictions, quarantine requirements, illness among workers, and limitations on the number of personnel permitted on construction sites. These conditions reduced workforce capacity, disrupted work sequences, and delayed project completion, particularly for labor-intensive construction activities.

Material procurement was identified as the third highest risk, with a mean score of 3.58. The pandemic disrupted both domestic and international supply chains through manufacturing slowdowns, transportation restrictions, and fluctuating market demand. These disruptions resulted in delayed material deliveries, shortages of essential construction materials, and increased material prices, all of which adversely affected project schedules, construction costs, and overall project performance.

Overall, the findings demonstrate that pandemic-related risks were multidimensional and interconnected. Health-related risks triggered labor shortages, while supply chain disruptions further constrained project execution. This highlights the need for construction risk management frameworks that integrate occupational health, workforce planning, and supply chain resilience to improve preparedness for future large-scale disruptions.

3.2. Activity Level Analisys of Pandemic Risks

Table 2. Activity Level Impact Assement

Construction Activity	Mean Score	Rank
Mansory Work	3.79	1
Earthwork	3.63	2
Concrete Work	3.49	3
Mechanical and Electrikal Work	3.32	4
Finishing Work	3.18	5

The results reveal that the effects of the COVID-19 pandemic were not uniformly distributed across construction activities, indicating that each activity exhibited different levels of vulnerability depending on its operational characteristics, labor requirements, and work environment.

Masonry work recorded the highest mean score (3.79), indicating that it was the construction activity most severely affected during the pandemic. Masonry operations typically require close collaboration among workers for material handling, bricklaying, plastering, and alignment tasks, making compliance with physical distancing measures particularly difficult. In addition, the labor-intensive nature of masonry work increased its susceptibility to workforce shortages resulting from illness, quarantine requirements, and mobility restrictions. These factors collectively reduced productivity and contributed to project delays.

Earthwork ranked second with a mean score of 3.63. Although earthwork often relies heavily on construction equipment, its execution still requires coordinated interaction among machine operators, surveyors, supervisors, and supporting labor. Pandemic-related labor shortages, restrictions on site occupancy, and interruptions in equipment mobilization reduced operational efficiency and affected work scheduling.

Concrete work ranked third with a mean score of 3.49. Concrete construction involves time-sensitive operations, including reinforcement installation, formwork preparation, concrete pouring, and curing. Delays in labor availability or material delivery can interrupt these sequential processes, potentially compromising construction quality and extending project duration.

Mechanical and electrical work recorded a moderate impact (mean = 3.32). These activities generally involve smaller specialized teams and can be scheduled more flexibly than structural works, reducing their exposure to pandemic-related disruptions.

Finishing work exhibited the lowest mean score (3.18), suggesting that it was relatively less affected by the pandemic. Finishing activities are commonly performed during the later stages of construction, often by smaller work crews operating in separated areas. Their greater scheduling flexibility and lower dependence on large numbers of workers enabled contractors to better adapt to health protocols and workforce limitations.

Overall, these findings demonstrate that labor-intensive construction activities were considerably more vulnerable to pandemic-related risks than activities requiring smaller or more specialized workforces. This variation highlights the importance of adopting activity-specific risk management strategies rather than relying solely on project-level approaches, enabling contractors to prioritize mitigation measures for the activities most susceptible to large-scale public health disruptions.

4. DISCUSSION

The results show that pandemic-induced risks have made notable changes to the construction risk profile by adding health-related risks as a primary factor that causes project uncertainties. Occupational health and safety have been found to be the most important risk factor in the present research, which aligns well with the findings of [2] and Kermanshachi et al. (2021) who have found that construction projects are highly susceptible to the spread of diseases because of extensive worker interactions and constantly changing nature of the construction sites.

Labor availability has been determined to be the second most important risk factor. The present research supports the conclusions reached by [8] according to whom mobility and quarantine restrictions imposed on workers decreased labor productivity.

One of the novel findings in the current research is the assessment of pandemic-induced risks at the level of activities. Previous researches considered pandemic-induced risks at the level of construction projects and identified project delays, lower productivity and increased cost as the outcomes [3] [1].

Masonry work was found to be the most vulnerable activity because it relies heavily on labor-intensive processes and close physical interaction among workers. Similar observations were reported by Kabir et al. (2022), who identified labor-intensive construction activities as particularly susceptible to pandemic-related disruptions. In contrast, finishing activities were less affected because they generally require fewer workers and offer greater flexibility in task scheduling. These findings suggest that project-level risk assessments alone may not adequately capture operational vulnerabilities during crisis situations. Therefore, activity-level risk assessment should be integrated into construction risk management frameworks to support more targeted mitigation strategies and improve project resilience against future disruptions.

Regarding this, there are several contributions that the present research makes to the existing knowledge base on construction risk management. Firstly, the current research involves health-related risks of the pandemic into the existing construction risk management framework. Secondly, this research uses a task-based risk assessment methodology. Finally, empirical data are generated in the case of Indonesia where manual labor is still widespread in construction.

The findings of this research increase the scientific knowledge of the construction risk management area by revealing an uneven distribution of the pandemic-related risks among the various construction activities. In accordance with the findings of this research, the most important risk factors during the pandemic period were occupational health and safety (mean = 3.82), labor availability (mean = 3.71), and material procurement (mean = 3.58).

In addition, the masonry activity received the highest average score of vulnerability (mean = 3.79), the earthworks activity got the second-highest average score (mean = 3.63), while the third place was taken by the concrete work activity (mean = 3.49). Thus, the findings of the research prove the need to incorporate the concept of health risks into the current models of construction risk management and analyze risks on the level of activities rather than projects.

6.2. Practical Implications

The findings from this research will be beneficial to construction practitioners in mitigating crisis situations during their future projects. Since those construction processes, which are labor dependent, for example, bricklaying process and earthwork, have been identified to be very susceptible to disruptions due to pandemic, then such activities should be prioritized while addressing such risks.

Some of the approaches are employee scheduling in shifts, health check-up of employees, contingency plan for employees, and material inventory management. Additionally, carrying out risk assessments in relation to activities will enable the stakeholders of the construction project to manage their resources without disturbing the schedules of the project.

On the other hand, the current research is associated with some limitations. First, the current research is based on questionnaire data, and therefore it can be biased by the perceptions of respondents. Second, the current research deals only with construction projects in Indonesia. It is recommended that further studies should be carried out using large samples and employing advanced techniques of data analysis such as SEM or multivariate analysis for the purposes of examining risk factors in connection with the pandemic. Further studies might take into account the use of digital technologies including BIM, AI, and digital monitoring.

5. CONCLUSION

This study examined the impact of pandemic-related risks on construction projects through an activity-level risk assessment. The findings indicate that occupational health and safety (OHS), labor availability, and material procurement were the most significant risk factors affecting construction project performance during the COVID-19 pandemic. Among the construction activities analyzed, masonry work was identified as the most vulnerable, followed by earthwork and concrete work, reflecting the greater susceptibility of labor-intensive activities to workforce shortages, health restrictions, and operational disruptions.

The results demonstrate that pandemic-related risks are not uniformly distributed across construction activities. Instead, the level of risk exposure varies according to the operational characteristics, labor intensity, and resource dependency of each activity. This finding highlights the limitations of conventional project-level risk assessments and underscores the importance of incorporating activity-level analysis into construction risk management.

The primary contribution of this study is the introduction of an activity-based perspective for assessing construction risks during large-scale public health emergencies. From a practical standpoint, the findings suggest that contractors and project managers should adopt activity-specific mitigation strategies, prioritizing labor-intensive activities through enhanced health protocols, workforce contingency planning, and more resilient material procurement practices. Such targeted approaches can improve project resilience and minimize disruptions during future crises.

From a theoretical perspective, this study extends construction risk management literature by integrating health-related risks into traditional risk assessment frameworks and demonstrating the value of activity-level analysis in supporting more informed risk prioritization and decision-making under crisis conditions. Future research may further validate this framework across different project types, procurement methods, and geographical contexts to enhance its broader applicability

REFERENCES

[1] Alsharef, A., Banerjee, S., Uddin, S. M. J., Albert, A., & Jaselskis, E. J. (2021). Early impacts of the COVID-19 pandemic on the United States construction industry. International Journal of Environmental Research and Public Health, 18(4), 1559. https://doi.org/10.3390/ijerph18041559

[2] Araya, F. (2021). Modeling the spread of COVID-19 on construction workers: An agent-based approach. Safety Science, 133, 105022. https://doi.org/10.1016/j.ssci.2020.105022

[3] Assaad, R., & El-Adaway, I. H. (2021). Impact of COVID-19 on the construction industry: Lessons learned. Journal of Management in Engineering, 37(2), 04020108. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000906

[4] Cynthia, G., (2023). The Impact of COVID-19 Pandemic on The Construction Projects in Indonesia: Identifying the Risks from the Stakeholders' Perspective. International Journal of Architecture Urbanism 7(2):279-287. https://doi.org/10.32734/ijau.v712.13510

[5] Gamil, Y., & Alhagar, A. (2020). The impact of pandemic crisis on construction projects. International Journal of Construction Management, 22(2), 1–10. https://doi.org/10.1080/15623599.2020.1721160

[6] International Organization for Standardization (ISO). (2018). ISO 31000:2018 Risk Management—Guidelines. ISO.

[7] Kerzner, H. (2022). Project Management: A Systems Approach to Planning, Scheduling, and Controlling (13th ed.). Wiley.

[8] Marzouk, M., & Elsharkawy, M. (2021). Impact of COVID-19 on construction supply chain. Journal of Construction Engineering and Management, 147(6), 04021038. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002098

[9] Project Management Institute (PMI). (2021). A Guide to the Project Management Body of Knowledge (PMBOK® Guide) (7th ed.). Project Management Institute.

[10] Rezakhani, P. (2012). Classifying key risk factors in construction projects. Buletinul Institutului Politehnic din Iaşi, 58(2), 27–38.
[11] Shen, W., Tang, W., Wang, S., & Duffield, C. (2021). Resilience-based risk management for construction projects under extreme events. Automation in Construction, 132, 103948. https://doi.org/10.1016/j.autcon.2021.103948
[12] Vu, T.-V., Vo-Thanh, T., Nguyen, N. P., Nguyen, D. V., & Hsiao, C.-Y. (2022). The COVID-19 pandemic: Workplace safety management practices, job insecurity, and employees' organizational citizenship behavior. Safety Science, 145, 105527. https://doi.org/10.1016/j.ssci.2021.105527
[13] Wang, J., Wu, P., Wang, X., & Shou, W. (2020). The impact of COVID-19 on construction projects: A risk management perspective. International Journal of Project Management, 38(8), 476–489. https://doi.org/10.1016/j.ijproman.2020.08.003