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The Risk Assessment and Human Risk Control in Indonesian Power Plant

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ABSTRACT

Efforts to enhance labor productivity are intrinsically linked to the improvement of Occupational Health and Safety (OHS) standards. The research focused on the optimization of OHS by conducting a COVID-19 risk assessment, with the goal of identifying and implementing Human Resource (HR) risk control measures to augment employee performance. In employing a qualitative methodology, the data were amassed through a combination of interviews, observations, and document analysis involving a diverse group of 23 respondents from various departments. The risk assessment process was meticulously structured into four phases: identification of causes, implementation of preventive measures, development of recovery strategies, and evaluation of consequences. The researchers organized the data into primary and secondary categories for analysis and utilized the Bow Tie method to elucidate the findings. The analysis reveals that the human factor, specifically employees' non-compliance with safety protocols, poses the greatest risk for virus transmission. The result identifies the warehouse, workshop, administration building, and Coal Handling Control Building (CHCB) as the most critical areas requiring stringent risk controls. The results also provide an overview in preparing the basis for Corrective Action and Preventive Action (CAPA). It provides benefits for implementing OHS in power plant companies through recommendations such as evaluation, preventive action, and risk control through COVID-19 risk assessment. Finally, the research delineates strategies for managing risks through preventive measures and recovery processes to mitigate the impacts and consequences associated with these hazards.

Keywords: risk assessment, human risk control, Indonesian power plant

INTRODUCTION

COVID-19 is a pandemic that affects all sectors of the world. The number of people infected with the virus is rising, and Wuhan, China, is thought to be where it first appeared. This pandemic is a big blow to every industrial sector, starting with resources, productivity, and profits (Ambarwati et al., 2022). In this case, COVID-19 has also provided changes in labor productivity (Baharin et al., 2020; Widarni & Bawono, 2021). Organizations employ various strategies to mitigate substantial financial losses to navigate economic downturns. Such measures are pivotal for maintaining labor productivity, ensuring operational continuity, and minimizing financial deficits (Rugulies et al., 2021). Enhancing labor productivity is deemed essential for organizational success. A crucial factor in this enhancement is the commitment of the workforce. Without such dedication, notable improvements in productivity are unlikely to be realized (Ambarwati et al., 2022; Pascarella et al., 2020).

Following the Collective Labor Agreement, all workers must actively increase the company's productivity. The company carries out mitigation in the

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prevention and control of the Coronavirus following the Regulation of the Minister of Health no. HK 01.07/ Menkes/328/2020, which contains "Guidelines for Prevention and Control of Corona Virus Disease 2019 (COVID-19)" in office and industrial workplaces to support business continuity during a pandemic (Khusufi et al., 2023; Rupiwardani et al., 2022; Susilo et al., 2020). Industries focusing on Occupational Health and Safety (OHS), such as power generation firms, are compelled to initiate measures aiming to boost labor productivity (Saputra & Mahaputra, 2022). The enhancement of labor productivity is intrinsically linked to OHS initiatives, which serve as a crucial mechanism for safeguarding employees during work hours (Marzuki et al., 2021; Perdana, 2021; Setiawan & Astutik, 2022). Addressing OHS issues and promptly rectifying workplace accidents are ongoing concerns within organizations (Grandez et al., 2022; Nurissa'adah et al., 2022; Saputra & Mahaputra, 2022).

The application of OHS in power plant companies is very necessary. By paying close attention to OHS, the safety and health of employees can be guaranteed. Hence, losses and accidents that occur can be prevented or minimized to as little as possible. Every company must have OHS, especially large-scale companies like power plants. So, employees can be effective at work and avoid casualties and material losses (Ahmad, 2022; Firmansyah et al., 2021; Mappeasse & Wijaya, 2021). In addressing these concerns, companies must actively engage in risk management. It involves risk assessments and a structured approach to averting losses, damages, or injuries at work (Kryukov et al., 2021; Pallocca et al., 2022). The importance of self-assessment in risk management is underscored in Government Regulation No. 60 of 2008, highlighting it as a standard procedure for risk identification, analysis, and evaluation (Sari et al., 2019). Moreover, the Government Internal Control System and the Spatially Integrated Policy Infrastructure (SIPI) emphasize the significance of risk assessment within governmental operations, advocating for enhanced employee care by superiors. It is very important to achieve goals effectively and efficiently (Ahmad, 2022; Saputra & Mahaputra, 2022). In addition to achieving the goal of risk assessment, it is also essential to break the rope of the spread of COVID-19.

In previous studies, there have been many studies on risk measurement in manufacturing companies using various methods (Hidayah et al., 2022; Mawiestin et al., 2021; Ridwan et al., 2022; Sobirin et al., 2022). Previous research on COVID-19 risk assessment within the service sector has indicated a widespread vulnerability of employees and clients to the virus, underscoring the urgency of implementing comprehensive risk management strategies. It includes 93% near miss, 4% uninjured, 3% unexpected events, and 0% sentinel events (Firmansyah et al., 2021). Other studies mention that distributors who store goods in warehouses during the pandemic due to increased online shopping make the warehouses the highest risk of COVID-19 transmission. Hazard Identification and Risk Assessment – Aspect Impact (HIRA-AI) method result in 38 hazards and 42 risks (Ardiana & Hasibuan, 2022). In addition, previous research conducted at (Persero) UPK PLTU Tambora during COVID-19 shows that OHS is very important to be implemented in companies with a purposive sampling stage in sampling (Suprianto et al., 2021). However, there have not been many studies related to measuring the level of risk of human resources due to COVID-19 in power plants with a high level of risk (Hidayah et al., 2022; Mawiestin et al., 2021; Ridwan et al., 2022; Sobirin et al., 2022). The risks can be interpreted as all possibilities that can occur and have impacts and consequences. It will also give rise to risk indicators, where this risk is in the form of pain or danger. In addition, these risks provide financial and physical losses (Ricardo et al., 2022).

The usual risk assessment used in addition to the Failure Mode and Effect Analysis (FMEA) method is the Bow Tie method. The Bow Tie method is usually in the form of a picture or diagram in the form of a bow tie. This diagram contains a relationship analysis and a hazard scenario. The diagram visualizes the relationship between causes and conditions of disturbance and damage that can trigger a risk leading to a high risk of accidents (Taleb-Berrouane et al., 2021). Then, it also has the actions that must be taken or prepared to reduce the resulting impact (Georgousoglou et al., 2022; Ambarwati et al., 2022). Previous research (Georgousoglou et al., 2022; Rachmawati et al., 2022) shows that the productivity approach used is to find out how incentives are obtained as a result of the productivity of each employer, and the results of incentives that have been formulated provide value higher incentives than before (Anwar & Abdullah, 2021; Sitopu et al., 2021). Then, another previous research shows the identification of OHS risks and risk assessment for OHS control. Using a Bow Tie analysis that forms the basis for preparing corrective and preventive actions can focus on risk control in increasing labor productivity (Supriyatna et al., 2020).

The research distinguishes itself by focusing on risk assessment through Human Resources (HR) activities. It diverges from prior research that is primarily concentrated on risk assessment related to production processes or machinery within organizations (Huang et al., 2022). Moreover, earlier investigations have been limited to developing experimental tools aiming at diminishing the severity of influenza (Zwanka & Buff, 2021). Distinctively, another body of research categorizes risk assessment into a five-tier hierarchy: elimination, substitution, engineering controls, administrative controls, and Personal Protective Equipment (PPE). The impact of risk assessment on the HR Certification Infrastructure Development Project of the National Cyber and Sandi Agency is further evidenced through surveys and correspondences (Sobirin et al., 2022).

Meanwhile, risk assessment in OHS is preventive so companies can find problems and assess risks (Hidayah et al., 2022). Given the dynamic nature of human behavior, which is prone to change, there is a pressing need for further research in HR-related risk assessment. The research undertakes a comprehensive analysis across four stages to address this need: identification of risk causes, implementation of anticipatory measures, formulation of recovery strategies, and evaluation of potential consequences. This multifaceted approach aims to modify human behavior, particularly emphasizing the consequence stage, where non-compliance with anticipatory actions can lead to incidents. The imposition of sanctions or the establishment of guidelines based on an analysis of causes, preventive measures, recovery strategies, and consequences is proposed to mitigate such risks. The research findings are intended to offer actionable recommendations for corporate management, serving as a foundational basis for policy formulation related to COVID-19 risk management.

The research is motivated by the large number of cases of COVID-19 virus in power plant companies. For example, as many as 123 infected workers (2019−2020) were from the administration building, warehouse, workshop, and Coal Handling Control Building (CHCB). The large number of workers exposed to the COVID-19 virus makes research focus on controlling human risk through risk assessment after a pandemic. In this case, the research focuses on assisting and optimizing OHS through a COVID-19 risk assessment and supporting workforce productivity during a pandemic. The research aims to identify risk resolution clearly and comprehensively by prioritizing problems and issues, as well as targeted solutions in power plant companies. The research uses the Bow Tie method, which visualizes events or risks based on prevention, causes, recovery, and consequences (Huang et al., 2022; Schröder et al., 2020; Wahab et al., 2021). Companies can use the research results to reduce the risk of COVID-19, optimize OHS, and improve employee performance. In addition, the research will help to regulate and make policies and reference material to improve the quality of the work environment in power plant companies.

METHODS

The researchers apply a qualitative approach to collect data and the Bow Tie method for data analysis to obtain more comprehensive results by looking at cause, preventive, recovery, and consequences assessment systems. However, the research has limited problems related to the risk assessment of COVID-19. The research provides an appropriate analysis starting from the reasons or causes, prevention, recovery, and consequences. In processing data, researchers must also ensure the completeness of the data. Therefore, there are three techniques that researchers choose to conduct research. The three techniques are interviews, observation, and documentation.

The initial stage in data collection is conducting interviews. Interviews need to be more structured and done more flexibly because researchers only ask important points when collecting data through interviews. Researchers also select important informants to provide more detailed and comprehensive information. Last, researchers use a purposive sampling technique to identify informants as experts in their fields when selecting informants (Andrade, 2021; Campbell et al., 2020). The informants' criteria are permanent employees with a minimum working period of five years. The employees understand the work process in each field—judging from the position held, such as at least the supervisory level or one of the members of the Coronavirus task force. Interviews are conducted using Zoom as a medium to find information on related parties. In PT PLN Nusantara Power, K3 & Security Paiton 9, Human Resources Department (HR), Civil-General, and Corporate Social Responsibility (CSR), as well as the company's doctor and operations, are some of the people the researchers talk to during the research process. In the process, there are 23 respondents from various fields: 9 people from K3 & Security Paiton 9, 6 people from the HR field, 3 people from the Civil-General and CSR division, 3 people from the company's doctor and 2 people from the operational section. A total of 23 respondents are included in the COVID-19 cluster unit.

The subsequent phase involves conducting field observations through a participatory approach, with the observation period segmented into three distinct shifts. Observations are systematically carried out in various locations, including the canteen, areas designated for employee entry and exit, places of worship, employee training facilities (PJB Academy), the safety briefing room, pantry, lobby reception, meeting rooms, toilets, the Coal Handling Control Room (CCR) for the main unit (production), CHCB, the administration building, workshop, warehouse, among others. The measurement tool is Bow Tie analysis. The research analysis is presented with a Bow Tie diagram. This diagram also explains in detail the initial cause of the risk, anticipation, recovery, and consequences that occur when the risk has spread widely. Bow Tie analysis also provides an overview of proactive risk management on the left side: cause and prevention. Meanwhile, on the right side of protective risk management, it has recovery and consequences (Alijoyo et al., 2021).

The integration of data collected from these observations augments the research, allowing for a comprehensive analysis. Researchers meticulously analyze and categorize the data into primary and secondary sets, enhancing the depth and breadth of data analysis. A triangulation process involving multiple data sources and methodologies is employed to ascertain the reliability and validity of the collected data, thereby ensuring the integrity of the data. Following the collection phase, data analysis is conducted employing the Bow Tie method, a systematic approach that delineates the causes

and consequences of identified hazards. From the interviews and observations, the four most significant risks are selected to analyze the causes and impacts and the prevention and recovery from those risks that have occurred or are likely to occur. Therefore, the final results of the research are in the form of suggestions and data processing. To further validate the research findings, the researchers undertake a series of tests to assess the data's validity and credibility. It includes a dependability test, ensuring consistency in the results obtained, and a transferability test, which evaluates the external validity and applicability of the research findings to other contexts. Finally, the researchers use a confirmability test. It is conducted with an FGD with sources to see whether many parties agree on the results.

RESULTS AND DISCUSSIONS

The results are obtained from respondents who have been interviewed. From Table 1 (see Appendices), it can be seen that there are 23 respondents who have been invited to the research. They are senior supervisor, assistant officers, junior officers, company doctors, and general civil and CSR officers. From the results of interviews conducted by researchers, four places have the potential to transmit the COVID-19 virus. These places are prioritized for immediate follow-up so that the virus does not spread further. The places are the warehouse, administration building, workshop, and CHCB.

In Table 2 (see Appendices), the analysis reveals that the workshop area within power plant operations presents the most significant risk factor. This workspace, designated for employees to engage with essential machinery for the power plant's functionality, lacks adequate handwashing facilities. It is solely equipped with machinery. Hence, it allows unrestricted employees' access. Consequently, this deficiency propels the risk level in the workshop to surpass other areas. In addition, an exhaust fan does little to mitigate the heightened risk of COVID-19 transmission. The primary contributors to this elevated risk include non-compliance with health protocols by employees, unhygienic conditions in certain areas like restrooms, and an absence of thorough sterilization and sanitation measures, facilitating rapid virus proliferation.

Mitigation strategies for the workshop area include several key measures. Initially, raising employee awareness about the risks associated with COVID-19 is crucial. Subsequently, regulating the flow of personnel into and out of the workspace can further reduce exposure. Then, providing hand sanitizers and soap in restrooms constitutes an additional preventive step. The installation of banners promoting adherence to health protocols, coupled with the enforcement of sanctions for non-compliance and the regular sterilization of the workspace, are also essential components of a comprehensive risk management strategy.

Without such preventive measures, the rate of virus transmission can escalate rapidly, leading to widespread infection among employees. Moreover, the potential for the virus to mutate and persist within the machinery underscores the urgency of implementing effective control measures. In scenarios where infection occurs, minimizing physical contact and encouraging the use of personal protective items, such as three-ply masks, alongside the provision of multivitamins, can serve as effective recovery strategies.

According to the findings presented in Table 3 (see Appendices), the warehouse holds the second-highest risk level. This warehouse or administrative space serves as a hub for the influx and outflow of goods, including international shipments necessitating documentation. The need for air conditioning varies within this space, dictated by the temperature sensitivity of certain materials, whereas areas without such requirements rely on exhaust fans and direct air vents for ventilation. A notable concern is the unrestricted access granted to employees, contributing to procedural non-compliance. Additionally, a significant shortfall in sterilization practices for both the premises and the goods themselves exacerbates the risk of virus transmission.

The implementation of stringent protocols is imperative to mitigate these risks. The protocols include the establishment of sterilization procedures for incoming and outgoing goods, regular monitoring and inspection of these items, and the assignment of dedicated personnel to oversee room sterilization. Such measures are vital to curtailing the potential for widespread virus dissemination, particularly considering the possibility of the virus persisting on warehouse items and transforming the space into a conduit for transmission to employees. In the event of risk realization, comprehensive strategies for containment and mitigation are essential. These strategies should encompass the reinforcement of cleaning protocols within the warehouse, limit employees' access to reduce potential exposure, establish isolation areas for individuals testing positive for COVID-19, enforce self-sanitization measures upon handling goods, and institute a schedule for regular or intermittent room sterilization. Collectively, these measures aim to safeguard the health and safety of employees while maintaining operational integrity.

Table 4 (see Appendices) positions the administration building as the third highest-risk location within the power plant's operations. This building functions as the central administrative hub, housing numerous employees alongside essential office and Information Technology (IT) infrastructure. The elevated risk level in this area primarily stems from inadequate adherence to health protocols by the staff, insufficient air circulation, lack of spatial partitions to enforce distancing, breaches in social distancing guidelines, and environments heavily reliant on air conditioning.

The implementation of several corrective measures is recommended to mitigate these risks.

Enhancing air filtration through the use of exhaust fans, reducing reliance on air conditioning to prevent air stagnation, establishing and enforcing a social distancing policy, discouraging the shared use of office equipment, monitoring employee movement to and from the area, imposing penalties for non-compliance with health measures, and facilitating spatial separation among employees are key strategies. These preventative actions aim to avert potential outcomes, such as increased vulnerability of employees to the virus, the persistence or mutation of the virus within the environment, unsterilized workspaces, and advisories from health authorities. For instance, where risks materialize, recovery efforts should focus on minimizing physical contact, conducting thorough sterilization of the premises, monitoring and assessing staff health, introducing humidifiers to improve air quality, and regularly scheduling deep cleaning procedures. These measures are designed to ensure the health and safety of employees while maintaining operational efficiency within the administrative building.

In concluding the risk analysis, the CHCB is identified as one of the areas with a significant risk level. The CHCB, an essential area for managing coal transfer operations, is characterized by its secure environment and reliance on air conditioning without specific entry requirements for employees. According to Table 5 (see Appendices), the primary risk within the CHCB stems from a lack of adherence to health protocols by employees, insufficient screening and sterilization upon entry, inadequate company oversight regarding personnel movement, and poor cleanliness in communal areas. Several preventive measures are proposed to mitigate these risks. The measures include the establishment of a checkpoint for personnel screening, the introduction of mandatory sterilization processes, regular cleaning of communal areas, and the consistent application of sterilization practices throughout the facility (Mwaruta, 2022). The potential consequences of unaddressed risks in the CHCB include a high likelihood of virus transmission among employees (Susilo et al., 2020).

Suggested recovery strategies emphasize the importance of addressing these risks with urgency and partnering with referral hospitals, implementing standard operating procedures (SOPs) for room access, establishing observation rooms for potential cases, enforcing reporting protocols for affected employees, sterilizing room thoroughly, and ensuring the availability of protective equipment (Loosemore et al., 2019; Tang, 2020). The analysis, employing the Bow Tie method, highlights employees' discipline as a critical factor in virus transmission, noting the impact of group work and the use of communal facilities (Alauddin et al., 2020). It underscores the necessity of prioritizing risks and adopting a structured approach to control measures, including the Testing, Tracing, and Treatment (3T) system for managing COVID-19 exposure (Ambarwati et al., 2022). Effective mitigation relies on comprehensive efforts, mask usage, social distancing, and strict adherence to health protocols. These efforts aim to minimize the risk and impact of COVID-19 within the workplace (Das et al., 2021; Huang et al., 2022; Zareia et al., 2019).

The discourse elucidates that the identification of hazards is a pivotal strategy for risk reduction within organizational settings. A methodical approach encompassing observation, risk assessment, and the acquisition of necessary equipment and protocols is imperative. Regular inspections and audits of facilities and equipment are essential to ensure safety. Moreover, employing analytical techniques, such as Job Safety analysis, What-If analysis, Hazard and Operability studies, Fault Tree analysis, FMEA, and HIRA, facilitates a comprehensive understanding of potential hazards (Nurissa'adah et al., 2022). Moreover, conducting a thorough risk assessment is crucial for delineating effective measures to manage COVID-19 and enabling organizations to discern and implement necessary precautions and interventions (Sanni-Anibire et al., 2020). This process is instrumental in gauging the severity and potential impact of risks, thereby informing decision-making processes that significantly influence organizational safety and health outcomes (Putra et al., 2019; Zwanka & Buff, 2021). To ensure the efficacy of risk management efforts, a hierarchy of control measures, including elimination, substitution, engineering controls, administrative controls, and the use of PPE, must be meticulously applied, serving as foundational principles in occupational safety and health risk management (Ahmed et al., 2021).

CONCLUSIONS

The risk analysis undertaken identifies four critical areas requiring prioritized control measures: the workshop area, warehouse, administration building, and CHCB. The research shows that the workshop area has 28 corrective and 26 preventive action results. In the warehouse area, there are 16 corrective and 19 preventive action results. Then, in the administration building area, there are 19 corrective and 18 preventive actions. Last, CHCB has 15 corrective and 15 preventive actions.

The main thing that must be done is controlling and changing HR or employees. The research implications can be obtained from the in-depth analysis results by not neglecting the health and productivity of the employees. Then, it shows in detail, starting from the causes of why the risk can occur, the prevention that can be done, the consequences that can be obtained, and the solutions that can be done if the risk occurs. From here, the company can make policies or regulations for employees with the right Standard Operating Procedure (SOP).

The research provides recommendations for companies in making rules and policies and what must be done to reduce and control the risk of COVID-19 in the company. Researchers can recommend that companies prioritize risk control of labor activities

through the results of CAPA in four main areas: workshop, warehouse, administration building, and CHCB. CAPA results can be a guideline for controlling labor activity risks in increasing employee productivity in accordance with company targets.

For research limitation, it is only carried out in one power plant area, with limited objects. The research only focuses on the risk of labor activities and does not look at the external or internal side of the workforce. In addition, the research only uses a qualitative approach, where there are still many other approaches. Future research is expected to conduct risk assessments using measuring instruments or other methods and add other high-risk labor activities.

REFERENCES

Ahmad, F. (2022). Implementation of Occupational Safety and Health (K3) for increasing employee productivity. *Jurnal Economic Resources*, *5*(2), 365–376.

Ahmed, A., Alkahtani, M., El-Tamimi, A. M., Kaid, H., & Abidi, M. H. (2021). Developing a model for safety risk assessment under uncertainty for the manufacturing industry: A case study of Pole factory hazards in Riyadh, Saudi Arabia. *Mathematical Problems in Engineering*, 1–13.

Alauddin, M., Islam Khan, M. A., Khan, F., Imtiaz, S., Ahmed, S., & Amyotte, P. (2020). How can process safety and a risk management approach guide pandemic risk management? *Journal of Loss Prevention in the Process Industries*, *68*, 1–13.

Alijoyo, A., Wijaya, Q. B., & Jacob, I. (2021). *Bow Tie analysis (Analisis dasi kupu-kupu)*. CRMS.

Ambarwati, R., Yuliastri, D., & Sulistiyowati, W. (2022). Human resource risk control through COVID-19 risk assessment in Indonesian manufacturing. *Journal of Loss Prevention in the Process Industries*, *74*(January), 1–9.

Andrade, C. (2021). The inconvenient truth about convenience and purposive samples. *Indian Journal of Psychological Medicine*, *43*(1), 86–88.

Anwar, G., & Abdullah, N. N. (2021). The impact of human resource management practice on organizational performance. *International Journal of Engineering, Business and Management (IJEBM)*, *5*(1), 35–47.

Ardiana, A., & Hasibuan, S. (2022). Occupational health and safety risk identification and analysis of warehouse in distribution sector post pandemi COVID-19. In *Proceedings of the 3rd Asia Pacific International Conference on Industrial Engineering and Operations Management* (pp. 1868–1876). IEOM Society International.

Baharin, R., Syah Aji, R. H., Yussof, I., & Mohd Saukani, N. (2020). Impact of human resource investment on labor productivity in Indonesia. *Iranian Journal of Management Studies*, *13*(1), 139–164.

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., ... & Walker, K. (2020). Purposive sampling: Complex or simple? Research case examples. *Journal of Research in Nursing*, *25*(8), 652–661.

Das, S., Garg, A., Maiti, J., Krishna, O. B., Thakkar, J. J., & Gangwar, R. K. (2021). A comprehensive methodology for quantification of Bow-tie under type II Fuzzy data. *Applied Soft Computing*, *103*(May).

Firmansyah, M. H., Sahri, M., & Setianto, B. (2021). Implementation of occupational safety and health risk management in Islamic Hospital Surabaya A. Yani. *Medical and Health Science Journal*, *5*(2), 16–26.

Georgousoglou, K., Mouzakitis, Y., & Adamides, E. D. (2022). The application of the Bow Tie approach in the risk assessment of a municipal solid waste management system. In *IOP Conference Series: Earth and Environmental Science*. IOP Publishing.

Grandez, J. P., Padilla, R. D. P. L., & Benites-Alfaro, E. (2022). Reduction of the rate of accidents at work through the implementation of a occupational safety and health management system in the industrial electromechanical industry. *Chemical Engineering Transactions*, *91*, 319–324.

Hidayah, P., Herniwanti, & Zaman, M. K. (2022). Implementation of Occupational Safety and Health (K3) inspection as a work accident prevention effort in palm oil factory, Kampar Regency, Riau Province. *Science Midwifery*, *10*(3), 2215–2224.

Huang, Y., Zhang, Z., Tao, Y., & Hu, H. (2022). Quantitative risk assessment of railway intrusions with text mining and Fuzzy rule-based Bow-Tie model. *Advanced Engineering Informatics*, *54*(October).

Khusufi, U. N., Fasya, A. H. Z., Handayani, D., & Wijaya, S. (2023). Literature review: Using HIRADC method analyzing the risk of work accidents in the manufacturing sector in Indonesia. *KESANS: International Journal of Health and Science*, *2*(5), 260–267.

Kryukov, E. V., Cherkashin, D. V., Reutskiy, I. A., Solntsev, V. N., Bucenko, S. A., Sobolev, A. D., ... & Kutelev, G. G. (2021). Differentiated approach to the implementation of preventive and anti-epidemic measures among military personnel based on the COVID-19 disease risk assessment scale. *Infectious Diseases: News, Opinions, Training*, *10*(2), 31–38.

Loosemore, M., Sunindijo, R. Y., Lestari, F., Kusminanti, Y., & Widanarko, B. (2019). Comparing the safety climate of the Indonesian and Australian construction industries: Cultural and institutional relativity in safety research. *Engineering, Construction and Architectural Management, 26*(10), 2206–2222.

Mappeasse, M. Y., & Wijaya, I. (2021). Studi penerapan kesehatan dan keselamatan kerja pada PLTU Punagaya Jeneponto. *Jurnal Media Elektrik, 18*(3), 94–99.

Marzuki, N., Afandi, D., & Rahayu, E. P. (2021). Analysis of the implementation of the Occupational Safety and Health (K3) program at the Madani regional hospital of Pekanbaru City in 2021. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, *4*(4), 9174–9180.

Mawiestin, A., Zamriana, W., Fitrina, R., & Indriyati, I. (2021). Evaluation on the application of Occupational

Safety and Health (K3) procedures at PT. IPC during pandemic using TheSWOT Analysis. *Advances in Transportation and Logistics Research*, *4*, 692–702.

Mwaruta, S. S. (2022). *Occupational safety and health training and performance of cement manufacturing firms in Kenya* (Doctoral dissertation). Jomo Kenyatta University of Agriculture and Technology.

Nurissa'adah, A., Ismiyah, E., & Rizqi, A. W. (2022). Analysis of Occupational Health, and Safety (K3) in the workshop area using the HIRA and 5S methods at PT. Ravana Jaya. *MOTIVECTION: Journal of Mechanical, Electrical and Industrial Engineering*, *4*(2), 161–174.

Pallocca, G., Moné, M. J., Kamp, H., Luijten, M., Van de Water, B., & Leist, M. (2022). Next-generation risk assessment of chemicals-rolling out a human-centric testing strategy to drive 3R implementation: the RISK-HUNT3R project perspective. *Alternatives to Animal Experimentation: ALTEX*, *39*(3), 419–426.

Pascarella, G., Strumia, A., Piliego, C., Bruno, F., Del Buono, R., Costa, F., ... & Agrò, F. E. (2020). COVID-19 diagnosis and management: A comprehensive review. *Journal of Internal Medicine*, *288*(2), 192–206.

Perdana, R. M. (2021). Analysis of Theory of Planned Behavior (TPB) in disobedience behavior towards Occupational Health and Safety (K3). *Journal of Economics, Business, and Government Challenges*, *4*(2), 139–146.

Putra, R. D., Sukandari, B., & Wihartono, W. (2019). Risk management of occupational safety and health in KRI docking project using Hazard Identification, Risk Assessment and Risk Control (HIRARC) method case study: PT. PAL Indonesia. *Journal Asro*, *10*(2), 76–91.

Rachmawati, A., Sukwika, T., & Ramli, S. (2022). Implementation of hospital risk management using Bowtie method. *Jurnal Mantik*, *6*(2), 2616–2623.

Ricardo, J., Manurung, E. H., & Hutagaol, K. (2022). Analisis risiko konstruksi pada proyek pembangunan rumah susun padat Karya Jakarta Utara. *Formosa Journal of Science and Technology*, *1*(4), 375–392.

Ridwan, A., Nuroni, A., Adelia, A., & Sonda, A. (2022). Analysis of occupational health and safety at a maritime warehouse using Hazard Identification, Risk Assessment and Risk Control (HIRARC). *Journal Industrial Servicess*, *8*(2), 187–192.

Rugulies, R., Sørensen, K., Di Tecco, C., Bonafede, M., Rondinone, B. M., Ahn, S., ... & Pega, F. (2021). The effect of exposure to long working hours on depression: A systematic review and meta-analysis from the WHO/ILO Joint Estimates of the Work-related Burden of Disease and Injury. *Environment International*, *155*(October), 1–37.

Rupiwardani, I., Sari, D., & Yuniastuti, T. (2022). HIRARC method for investigating worker behavior regarding risk management. *Asian Journal of Management, Entrepreneurship and Social Science*, *2*(04), 107–121.

Sanni-Anibire, M. O., Mahmoud, A. S., Hassanain, M. A., & Salami, B. A. (2020). A risk assessment approach for enhancing construction safety performance. *Safety Science*, *121*, 15–29.

Saputra, F., & Mahaputra, M. R. (2022). Building Occupational Safety and Health (K3): Analysis of the work environment and work discipline. *Journal of Law, Politic and Humanities*, *2*(3), 105–114.

Sari, D. P., Pujotomo, D., Wicaksono, P. A., & Yunanto, K. H. R. (2019). An integrated relative importance index, risk allocation and Bow Tie analysis for analyzing risks of the Amartha View Apartment development project. In *IOP Conference Series: Materials Science and Engineering*. IOP Publishing.

Schröder, I., Czornyj, E., Blayney, M. B., Wayne, N. L., & Merlic, C. A. (2020). Proceedings of the 2018 Laboratory Safety Workshop: Hazard and risk management in the laboratory. *ACS Chemical Health & Safety*, *27*(2), 96–104.

Setiawan, F., & Astutik, M. (2022). The effect of training, supervision and Occupational Safety and Health (K3) culture on employee performance. *Indonesian Journal of Law and Economics Review*, *17*, 1–14.

Sitopu, Y. B., Sitinjak, K. A., & Marpaung, F. K. (2021). The influence of motivation, work discipline, and compensation on employee performance. *Golden Ratio of Human Resource Management*, *1*(2), 72–83.

Sobirin, M., Putra, A. N., Fertilla, N. C., & Susanti, I. I. (2022). Analysis of types of Occupational Health and Safety Risk (K3) in erection work. *ARRUS Journal of Engineering and Technology*, *2*(2), 65–77.

Supriyatna, H., Kurniawan, W., & Purba, H. H. (2020). Occupational safety and health risk in building construction project: literature review. *Operational Research in Engineering Sciences: Theory and Applications*, *3*(1), 28–40.

Suprianto, S., Fitryani, V., Rahim, A., Rachman, R., & Pamungkas, B. D. (2021). Implementation of occupational safety and health policies during the COVID-19 Pandemic. In *2nd Annual Conference on Education and Social Science (ACCESS 2020)* (pp. 208–211). Atlantis Press.

Susilo, A., Rumende, C. M., Pitoyo, C. W., Santoso, W. D., Yulianti, M., Herikurniawan, H., ... & Yunihastuti, E. (2020). Coronavirus disease 2019: Tinjauan literatur terkini. *Jurnal Penyakit Dalam Indonesia*, *7*(1), 45–67.

Taleb-Berrouane, M., Khan, F., & Hawboldt, K. (2021). Corrosion risk assessment using Adaptive Bow-Tie (ABT) analysis. *Reliability Engineering & System Safety*, *214*.

Tang, K. H. D. (2020). A comparative overview of the primary Southeast Asian safety and health laws. *International Journal of Workplace Health Management*, *13*(6), 601–632.

Wahab, N. A. A., Aqila, N. A., Isa, N., Husin, N. I., Zin, A. M., Mokhtar, M., & Mukhtar, N. M. A. (2021). A systematic review on hazard identification, risk assessment and risk control in academic laboratory. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *24*(1), 47–62.

Widarni, E. L., & Bawono, S. (2021). Human capital, technology, and economic growth: A case study of

Indonesia. *Journal of Asian Finance, Economics and Business, 8*(5), 29–35.

Zareia, E., Yazdib, M., Khakzadc, N., & Reniersc, G. (2019). Safety assessment of process systems using Fuzzy Extended Bow Tie (FEBT) model. *Chemical Engineering*, *77*, 1027–1032.

Zwanka, R. J., & Buff, C. (2021). COVID-19 generation: A conceptual framework of the consumer behavioral shifts to be caused by the COVID-19 pandemic. *Journal of International Consumer Marketing*, *33*(1), 58–67.

APPENDICES

Table 1 Respondents' Profile

No	Name	Position
1	Drajat Aribowo	Assistant Officer of Safety and Security Unit 1 and 2
2	Bagas Kencana Yulindra	Assistant Manager Safety and Security Unit 1, 2, and 9
3	Ksatrya Weda Utama Putra	Assistant Officer of Safety and Security Unit 1 and 2
4	Efendi Sudarmanto	Assistant Officer of Safety and Security Unit 1 and 2
5	Aulia Maulana Azkiya	Team Leader Safety and Security Unit 1, 2, and 9
6	Christia Putra Sentosa	Assistant Officer of Safety and Security Unit 1 and 2
7	Sukrisno	Assistant Officer of General Affair Unit 1 and 2
8	Sarjono	Assistant Officer of Safety and Security Unit 9
9	Hanafi Dwi Kurniawan	Assistant Officer of Safety and Security Unit 9
10	Nijo Haryadi	Junior Officer Safety & Security Unit 9
11	Djoyo Mulyono	Junior Officer Safety & Security Unit 9
12	Fahrurridzal Ibnu Mafa	Assistant Officer of Safety and Security Unit 9
13	Ade Vicktor Cindy	Junior Officer Safety & Security Unit 9
14	Dr. Maharani	Company Doctors
15	Dr. Benny	Company Doctors
16	Puji Hartono	Paramedics
17	Maida Muzayyanah	Assistant Manager of Human Resources and Finance Unit 1, 2, and 9
18	Misbiantoro	Assistant Officer of Human Resource Unit 1 and 2
19	Diah Nurul Khotimah	Assistant Officer of Human Resource Unit 1 and 2
20	Dedy Andrianto	Junior Officer of Human Resource Unit 9
21	Hendrik Setiawan	Assistant Manager of Maintenance and Outage Management Unit 1, 2, and 9
22	Putranto	Assistant Officer of Engineering Unit 2
23	Sukirman Hadi Prayitno	Assistant Officer of General Affair Unit 1 and 2

Note: Occupational Health and Safety (OHS) and Corporate Social Responsibility (CSR).

Table 2 Workshop Analysis Results

Cause	Preventive	Recovery	Consequence
Employees do not implement health protocols (CA1. 1)	1. Implementation of health protocols (P11.1) 2. Regulations for limiting the number of people in each room (P11.2) 3. Sanctions for those who do not comply with health regulations and protocols (P11.3) 4. Health protocol banners in every workspace (P11.4)	1. Bringing items that are frequently used from home (R11.1) 2. Not sharing personal equipment (office work) (R11.2). 3. Giving warnings to companies about wearing masks by the COVID-19 Task Force (R11.3). 4. More job administration online (R11.4). 5. Provision of multivitamins regularly to employees (R11.5) 6. Implementation of medical check-ups for employees (R11.6)	Employees are infected with a virus originating in the work area of the workshop room (closed) (C1.1)
The toilet room and sink are not clean and sterile (CA1.2)	1. Provision of hand washing soap and hand sanitizer in every toilet room and sink (P12.1) 2. Good sanitation in the toilet room and sink (P12.2)	1. Scheduling the cleaning of the toilet room and sink (R12.1) 2. Scheduling the sterilization of the toilet room and sink (R12.2)	The virus survives and mutates in the workshop (C1.2)
The condition of the admin's work desk that is not far (≤ 1.5 meters) (CA1.3)	1. Installation of partitions or booths for employees' work desks (P13.1) 2. Briefing employees about health protocols every morning (P13.2) 3. Scheduling WFH and WFO (P13.3)	1. Placement or installation of lines to know a safe distance (R13.1). 2. Warnings to employees in case of negligence and violations (R13.2)	Employees quickly catch each other with a high level of risk (C1.3)
There is a lack of sanitation in the room (CA1.4)	1. Scheduling room sanitation maintenance (P14.1) 2. Special personnel for the maintenance of room sanitation (P14.2)	1. Routine sterilization in each workroom (R14.1) 2. Spraying the sterilization of employee work desks regularly (R14.2)	The room is not sterile, or there is still a virus COVID-19(C1.4)
There is a movement of the required tools held by employees in the workshop room (CA1.5)	1. A banner for the use of hand sanitizer and washing hands (P15.1) 2. Availability of disposable gloves (P15.2)	1. Reducing physical contact between employees (R15.1) 2. Provision of hand sanitizer in each employee's workroom (R15.2) 3. Additional provision of places for washing hands (R15.3)	Transmission of the virus is through intermediary equipment (tools) (C1.5)
The employees take breaks together in the dining room and worship (CA1.6)	1. Health protocol banners in rest and worship rooms (P16.1) 2. Turning on the fan (exhaust fan) when employees are in the break and worship room (P16.2) 3. Opening doors and windows when employees are in the break and prayer room (P16.3) 4. Regular replacement and cleaning of worship equipment and cutlery (P16.4) 5. Bringing their worship equipment and cutlery (P16.5) 6. Regular sterilization of places of worship in the dining room (P16.6) 7. Provision of hand sanitizers in rest and worship rooms (P16.7) 8. Provision of handwashing facilities and soap in rest and worship areas (P16.8) 9. Installing physical distancing signs for employees who take turns to rest and worship (P16.9)	1. Wearing three-ply masks while in the rest and worship rooms (R16.1) 2. Washing hands with soap before entering the break room (R16.2) 3. The time limit of 20 minutes while in rest areas and worship room (R16.3) 4. Pest control in the workshop area (R16.4) 5. Regular cleaning of the dining, worship, and restrooms (R16.5)	Transmission of the virus is from cutlery or worship items that are used together (C1.6)

Table 3 Warehouse Analysis Results

Cause	Preventive	Recovery	Consequence
Employees do not comply with health protocols (CA2.1)	1. Warning to every employee by the COVID-19 Task Force to always comply with health protocols (P21.1) 2. Regulations for preventing COVID-19 every time employees enter the room (P21.2) 3. Mechanism for sanctions for employees who do not comply with health protocols when entering the room (P21.3)	1. Prohibiting employees who have been exposed to the virus from coming to work (R21.1) 2. Providing limits on the room or a safe distance from the worktable (R21.2) 3. Scheduling routine sanitation and sterilization in each room (R21.3)	There is an increased potential for transmission of the COVID-19 virus (C2.1)
There is a lack of sterilization of goods in the warehouse (CA2.2)	1. Periodic monitoring of checking tools (P22.1) 2. Sterilization of existing and newly entered goods (P22.2)	1. Periodic cleaning of the warehouse area (R22.1) 2. Routine sterilization for each item (R22.2)	The virus will survive on the goods stored in the warehouse (C2.2)
There is a lack of sanitation in logistics storage space (CA2.3)	1. Routine sterilization scheduling (P23.1) 2. Special officer for the maintenance of warehouse room sanitation (P23.2)	1. Improving scheduling of room sanitation at least 2-3 times a week (R23.1) 2. Isolation room facilities if the employees are exposed to the COVID-19 virus (R23.3)	The warehouse room is a source of COVID-19 virus transmission (C2.3)
Goods are in and out without going through a sterilization procedure (originating from internal or external companies) (CA2.4)	1. Written regulations in the warehouse room regarding procedures for entering and leaving goods (P24.1) 2. Giving warnings and strict sanctions for violators (P24.2)	1. Limiting the number of people in the warehouse room (R24.1) 2. Wearing gloves when loading and unloading items (R24.2) 3. Using complete Personal Protective Equipment (PPE) in the warehouse space (R24.3) 4. Self-cleaning after entering and removing goods in the warehouse (R24.4) 5. Carrying out social distancing and physical distancing (R24. 5)	Virus transfer is very easy from goods that have been exposed to the COVID-19 virus to employees in the warehouse room (C2.4)
Employees share both personal and office equipment and supplies (CA2.5)	1. Advice to avoid sharing food and drinks (P25.1) 2. Maintaining personal and environmental cleanliness in the warehouse space (P25.2)	1. Identification of high-risk employees with targeted COVID-19 tests (R25.1) 2. Provision of special isolation rooms for employees (sudden illness) (R25.2)	The potential for transmission of COVID-19 between employees is very high (C2.5)

Table 4 Administration Building Analysis Results

Cause	Preventive	Recovery	Consequence
There is a lack of employee awareness of health protocols (CA3.1)	1. Health protocol banners in every room (P31.1) 2. Strict sanctions for employees who violate health protocols (P31.2) 3. Brief and outreach about the prevention of COVID-19 regularly (P31.3)	1. Avoiding physical contact continuously (R31.1) 2. Providing hand sanitizer facilities at each entrance. Then, the employees will enter the rapid disinfection booth before entering the UBJOM Paiton area (R31.2)	Employees are vulnerable to the COVID-19 virus (C3.1)
There is a lack of air circulation entering the office (CA3.2)	1. Availability of fans (exhaust fans) in each room (P32.1) 2. Minimizing the use of air conditioning (P32.2)	1. Scheduling cleaning of administrative rooms more frequently (R32.1) 2. Indoor use and supplying of three-ply masks (R32.2)	The virus survives and mutates in the administration building (C3.2)
People go in and out without being sterilized (CA3.3)	1. Checking everyone who enters the administration room (P33.1) 2. Implementation of strict social distancing indoors (P33.2)	1. Routine administration room sterilization (R33.1) 2. Regular cleaning schedule (R33.2) 3. Limiting the number of people in the administration room (R33.3)	The potential for transmission of COVID-19 is high because the room is not sterile (C3.3)
The workspace does not have frames or cubicles and violations of social distancing (CA3.4)	1. Provision of partitions or booths (P34.1) 2. Working table distance with limitation ≤ 1.5 meters (P34.2) 3. Regulation to limit the number of people in each room (P34.3)	1. Monitoring and evaluating the implementation of health protocols every period (R34.1) 2. Consultation with the health team and the COVID-19 Task Force regarding work procedures according to regulations (R34.2)	There is a warning from the COVID-19 Task Force team/local health office (C3.4)
The room condition is closed and full of air conditioning (CA3.5)	1. Social distancing rules (P35.1) 2. Minimizing the use of air conditioning (P35.2) 3. Air circulation and room sanitation according to standards (P35.3)	1. Routine sterilization scheduling (R35.1) 2. Provision of more air circulation (R35.2) 3. Provisions of air filter (R35.3) 4. Provision of humidifiers in each room as needed (R35.4)	The virus survives and mutates in the administration room (C3.5)

Table 5 Coal Handling Control Building (CHCB) Analysis Results

Cause	Preventive	Recovery	Consequence
Lack of officers' supervision towards employees when they are about to enter the CHCB room (CA4.1)	1. Imposition of strict sanctions if officers neglect to carry out their duties (P41.1) 2. Making posts for officers to check (P41.2) 3. Routine briefing on routine checking officers (P41.3)	1. Collaborating with referral hospitals for follow-up care (R41.1) 2. SOP for entering and leaving the system room (R41.2) 3. Observation room for transit before being referred to the hospital (R41.3)	Employees or employees come to work when sick (C4.1)
Employees do not comply with health protocols (CA4.2)	1. Sanctions for employees who violate implementing health protocols (P42.1) 2. Placement of screening facilities to check employee access in and out (P42.2) 3. Routine socialization and prevention of COVID-19 briefings (P42.3)	1. CHCB room sterilization routinely (R42.1) 2. Implementation of operational procedures during the COVID-19 alert period consistently (R42.2)	The potential for transmission of COVID-19 is faster (C4.2)
The cleanliness in the employees' break room is lacking (CA4.3)	1. Provision of facilities for hand washing (P43.1) 2. Routine cleaning of break room (P43.2) 3. Scheduling regular sterilization and disinfection (P43.3)	1. Reminder to wear a mask when not eating (R43.1) 2. Implementation of physical distancing between employees (R43.2) 3. Mandatory reporting for employees who are sick (R43. 3)	Healthy employees are infected with the COVID-19 virus (C4.3)
Employees go in and out without any screening or sterilization process (CA4.4)	1. Placement of screening or sterilization when entering the room (P44.1) 2. Sterilization around the CHCB room (P44.2)	1. Mandatory rules for screening and sterilization by special officers (R44.1) 2. Provision of complete PPE for checking officers (R44.2) 3. Provision of hand sanitizer for employees when entering the room CHCB (R44.3)	The virus enters the room, and the spread is very high (C4.4)

Note: Coal Handling Control Building (CHCB), Standard Operating Procedure (SOP), and Personal Protective Equipment (PPE).