Occupational Health and Safety (OHS) Risk Analysis Using Fishbone Diagram and Job Safety Analysis (JSA): A Case Study of Spray Booth and Oven Operations in the Automotive Engineering Laboratory of Universitas Negeri Makassar

Muh. Bhilal Halim[1*], Fauziah[2]
[1]Department of Automotive Engineering, Universitas Negeri Makassar
[2]Department of Mechanical and Industrial Engineering, Universitas Negeri Makassar

Corresponding Author's e-mail : *m.bhilal@unm.ac.id*

ARMADA JURNAL PENELITIAN MULTIDISIPLIN

e-ISSN: 2964-2981

ARMADA : Jurnal Penelitian Multidisiplin

https://ejournal.45mataram.ac.id/index.php/armada

Vol. 03, No. 12 Desember, 2025

Page: 485-492

DOI:
https://doi.org/10.55681/armada.v3i12.1937

Article History:
Received: November 22, 2025
Revised: Desember 10, 2025
Accepted: Desember 15, 2025

Abstract *: Occupational Safety and Health (OSH) in vocational laboratories is critical due to high-risk activities such as spray painting and oven drying involving chemical exposure, heat, and fire hazards. This study aims to analyze OSH risks in spray booth and oven operations at the Automotive Engineering Laboratory of Universitas Negeri Makassar using Job Safety Analysis (JSA) and Fishbone Diagram methods. A mixed descriptive approach was applied through observation, interviews with 15 respondents, and documentation review. Risk assessment was conducted using a risk matrix (likelihood × severity), followed by root cause analysis. The results show that the highest risk level occurs in spray painting activities with a score of R=16 (high risk), mainly due to VOC exposure. Most hazards are categorized as moderate risk (R=10–12), while low risk is R=9. Compliance with personal protective equipment usage is only 70%, indicating behavioral safety gaps. Fishbone analysis reveals that human and environmental factors are the dominant causes of risk. The integration of JSA and Fishbone provides comprehensive hazard identification and root cause analysis. These findings highlight that 60% of risks are moderate, 20% high, and 20% low, emphasizing the urgency of strengthening OSH systems in laboratory environments to prevent occupational accidents effectively.*

Keywords : *Occupational Safety and Health, Fishbone Diagram, Risk Assessment, Laboratory Safety*

INTRODUCTION

Occupational Safety and Health (OSH) is no longer considered merely an administrative aspect, but rather a strategic system that determines the sustainability of work activities, including within vocational education environments. Automotive engineering laboratories, as miniature representations of industrial settings, present significant risk complexity due to the interaction between humans, machines, materials, methods, and the working environment. Painting activities using spray booths and drying processes using ovens are among the high-risk operations due to the involvement of volatile chemical substances, high temperatures, and the potential for fire and explosion (Afrizal, 2023; Vikto, 2021).

Empirically, workplace accidents in Indonesia continue to show a concerning trend, particularly in technical sectors such as manufacturing and automotive industries. Abiezzart and Marga (2023) state that occupational accidents are still predominantly caused by human error and weak risk management systems. This is reinforced by Rosanti (2024), who reveals that increased work activities without strengthening OSH systems may lead to a higher frequency of accidents. In this context, OSH problems are not only related to the existence of procedures, but also to the effectiveness of their implementation and field supervision. These issues become more complex in educational laboratory environments, where users are not only skilled workers but also students who are still in the learning process. Anitasari and Widiyatmoko (2025) emphasize that automotive practical activities carry high risk levels, particularly those involving chemicals and heat. However, OSH implementation in laboratories is often still normative and not based on comprehensive risk analysis. Faizah and Nadroh (2025) also indicate that in automotive workshop activities, potential hazards such as chemical exposure and fire risks are often not systematically analyzed at each stage of work.

Specifically, spray booth processes generate exposure to volatile organic compounds (VOCs) that are hazardous to health, including respiratory disorders, irritation, and long-term toxic effects (Vikto, 2021). On the other hand, the use of ovens in drying processes increases the risk of burns and fire due to high temperatures and the accumulation of flammable vapors. Afrizal (2023) shows that spray booth areas are among the highest-risk zones due to the interaction of multiple interrelated factors. This indicates that a simple risk analysis approach is insufficient to understand the complexity of hazards involved. From a methodological perspective, various approaches have been used to analyze OSH risks, one of which is Job Safety Analysis (JSA). This method has proven effective in identifying potential hazards at each stage of work in a systematic manner (Yasinta et al., 2025). However, JSA has limitations in explaining causal relationships in accident occurrences. In other words, this method tends to be descriptive and is not yet capable of identifying root causes in depth.

In contrast, the Fishbone Diagram (Ishikawa Diagram) is a method used to identify the root causes of a problem comprehensively through a structured cause-and-effect approach. Aziz (2025) and Yulistio (2023) demonstrate that Fishbone Diagrams are effective in categorizing causal factors based on human, machine, method, material, and environmental aspects. Nevertheless, when used independently without work activity analysis support, this method may produce less operational recommendations. Based on these studies, a significant research gap can be identified. First, OSH research is still dominated by industrial sectors, while studies in educational laboratory settings remain limited (Salam & Ikhsanudin, 2025). Second, most studies employ single approaches such as JSA or HIRARC without integration with root cause analysis methods. Third, studies specifically examining risks in spray booth and oven operations using an integrative approach are still very limited.

Furthermore, OSH approaches that are not based on root cause analysis may result in superficial policy recommendations. Anggraeni (2025) emphasizes that effective risk control must be based on a comprehensive understanding of hazard sources, not merely visible symptoms. Therefore, a more comprehensive and integrative approach to OSH risk analysis is required.

Based on these considerations, the integration of Job Safety Analysis (JSA) and Fishbone Diagram is a relevant approach to be applied. JSA enables detailed identification of hazards at each stage of work, while the Fishbone Diagram helps identify the root causes of each detected hazard. By combining these two methods, risk analysis is expected to become more comprehensive, systematic, and capable of producing applicable recommendations.

Thus, this study aims to analyze occupational safety and health (OSH) risks in spray booth oven operations at the Automotive Engineering Laboratory of Universitas Negeri Makassar (UNM) using Job Safety Analysis (JSA) and Fishbone Diagram methods. This research is expected to contribute both theoretically to the development of integrative OSH risk analysis methods and practically to improving workplace safety systems in educational laboratory environments.

METHOD

This study employed a descriptive quantitative approach combined with qualitative analysis to examine occupational safety and health (OSH) risks in spray booth oven operations at the Automotive Engineering Laboratory of Universitas Negeri Makassar (UNM). This approach was selected because it is capable of providing a measurable representation of risk levels through quantitative calculations, while also offering in-depth explanations of the underlying causal factors through qualitative analysis. Thus, the study does not only focus on hazard identification but also seeks to uncover the root causes of the observed risks (Idaman et al., 2026; Yasinta et al., 2025).

In its implementation, the study integrates two main methods, namely Job Safety Analysis (JSA) and the Fishbone Diagram. The JSA method is used to break down each work activity in the spray booth and oven processes into detailed operational steps, enabling systematic identification of potential hazards at each stage. Subsequently, the Fishbone Diagram is applied to trace the cause-and-effect relationships of each identified risk by categorizing contributing factors into human, machine, method, material, and environmental aspects. The integration of these two methods allows for a comprehensive risk analysis, extending beyond surface-level identification to a deeper examination of root causes (Aziz, 2025).

The data sources in this study consist of both primary and secondary data that complement each other. Primary data were obtained directly through field observations of laboratory work activities and interactions with respondents involved in the operational processes. Meanwhile, secondary data were collected from supporting documents such as standard operating procedures (SOPs), accident reports, and relevant scientific literature on OSH. The use of both data types aims to strengthen the validity of the study through source triangulation, ensuring that the information obtained is not reliant on a single data source but can be verified from multiple perspectives (Hansabila, 2023).

Data collection was conducted using several integrated techniques, namely direct observation, semi-structured interviews, and documentation study. Observation was carried out to identify actual field conditions, including work stages, the use of personal protective equipment (PPE), and potential hazards occurring during the process. Semi-structured interviews were used to explore more in-depth information regarding work experience, understanding of OSH procedures, and respondents' perceptions of the risks encountered. Meanwhile, documentation studies were conducted to complement and verify data obtained from observations and interviews, particularly those related to OSH policies and their implementation in the laboratory. The combination of these three techniques enabled the collection of comprehensive, contextual, and accountable data (Junita et al., 2025).

The study involved 15 respondents consisting of 3 technicians/laboratory staff, 2 instructors or practical lecturers, and 10 student practitioners directly involved in spray booth and oven activities. Respondents were selected using purposive sampling based on specific criteria relevant to the research objectives. These criteria included direct involvement in work processes, experience in operating spray booth and oven equipment, and understanding of applicable operational procedures. The selection of this number and composition of respondents was based on considerations of role representation in laboratory activities, ensuring that the data obtained accurately reflects both the overall and detailed working conditions (Aswan, 2025; Mantovani, 2024).

The data analysis process was carried out in a systematic and staged manner, beginning with the identification of work activities using the Job Safety Analysis (JSA) method. At this stage, each work process was broken down into operational steps and then analyzed to identify potential hazards, possible impacts, and initial control measures already in place. A risk assessment was then conducted using a risk matrix by multiplying the likelihood and severity levels to determine the risk category.

Risks categorized as medium to high were further analyzed using the Fishbone Diagram to systematically identify their root causes. This analysis grouped contributing factors into five main aspects: human, machine, method, material, and environment, providing a comprehensive overview of the factors contributing to the occurrence of risks. The final stage of analysis involved developing risk control recommendations based on the OSH hierarchy of controls, which includes elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE).

Through this methodological framework, the study produces a risk analysis that is not only descriptive but also diagnostic and solution-oriented. Therefore, the methodology applied is considered relevant to the research objectives and capable of producing findings that are valid, systematic, and scientifically accountable.

RESULT & DISCUSSION

Result

The findings of this study were obtained through direct observation of *spray booth* and oven operations in the Automotive Engineering Laboratory of Universitas Negeri Makassar (UNM), structured interviews with 15 respondents (3 technicians, 2 instructors, and 10 students), and a review of occupational safety and health (OSH) documentation. Based on the Job Safety Analysis (JSA) conducted across four main work stages, namely material preparation, spray painting process, oven drying, and equipment cleaning, various potential hazards were identified at each stage of the operation.

Table 1. Identification of Potential Hazards and Risk Assessment in Spray

No	Work Stage	Potential Hazard	Impact	Likelihood (L)	Severity (S)	Risk Value (R=L×S)	Risk Category
1	Material preparation	Exposure to thinner/paint chemicals	Skin irritation, poisoning	3	4	12	Moderate
2	Spray painting	Inhalation of VOC fumes	Respiratory disorders	4	4	16	High
3	Spray painting	Fire hazard from flammable materials	Severe injury/fatality	2	5	10	Moderate
4	Oven drying	High temperature exposure	Burns	3	4	12	Moderate
5	Oven drying	Vapor explosion	Fatal accident	2	5	10	Moderate
6	Cleaning process	Chemical contact with skin	Irritation	3	3	9	Low

Based on the risk assessment results, most identified hazards fall into the moderate risk category (R = 10–12), while the highest risk level (R = 16) occurs during the spray painting process due to direct exposure to *volatile organic compounds* (VOC). These findings indicate that chemical exposure is the most critical hazard in spray booth operations.

Field observations revealed that compliance with the use of personal protective equipment (PPE) was approximately **70%**, indicating that not all operators consistently used safety equipment such as respirators and gloves. Additionally, the ventilation system in the spray booth was found to be suboptimal, contributing to the accumulation of hazardous fumes. This condition is consistent with the findings of Vikto (2021), which highlight that inadequate ventilation significantly increases the risk of respiratory disorders in workshop environments.

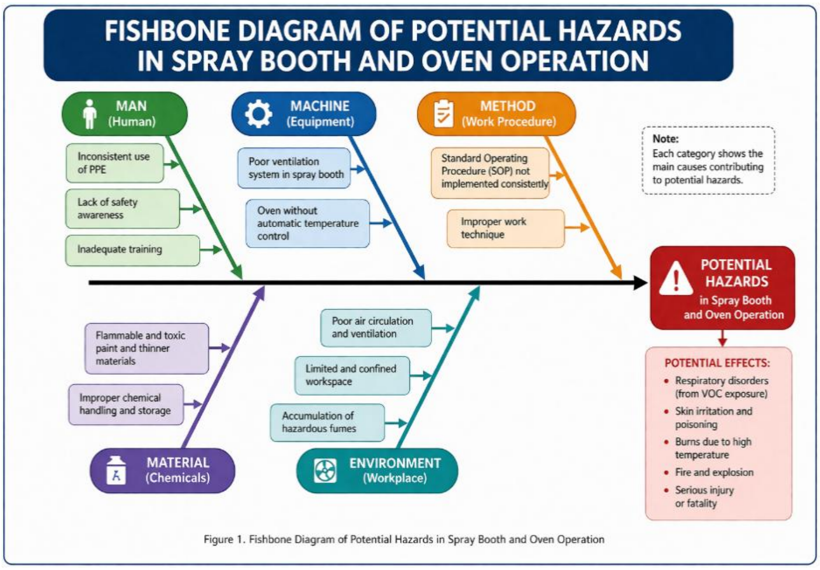

Figure 1. Fishbone Diagram of Potential Hazards in Spray Booth and Oven Operation

Interpretation of the diagram indicates that human (Man) and environmental (Environment) factors are the dominant contributors to potential occupational hazards in spray booth and oven operations. On the human side, inconsistent use of personal protective equipment (PPE), lack of safety awareness, and inadequate training significantly increase the probability of exposure to hazardous substances such as volatile organic compounds (VOC) and high-temperature surfaces. These behavioral deficiencies reflect weak safety culture and insufficient reinforcement of occupational safety procedures among operators.

From the environmental perspective, poor air circulation, limited workspace, and accumulation of hazardous fumes were identified as critical conditions that intensify risk levels, particularly during the spray painting and oven drying processes. These conditions contribute to prolonged exposure to toxic vapors and increase the likelihood of respiratory disorders and fire-related incidents. The dominance of these two factors suggests that technical controls alone are insufficient without addressing behavioral and environmental improvements simultaneously.

These findings are consistent with Salam and Ikhsanudin (2025) and Vikto (2021), who emphasized that inadequate workplace environmental control and low compliance with safety procedures are key determinants of occupational risk in laboratory and workshop settings. Furthermore, the results reinforce the importance of integrated OSH management systems that address both human behavior and workplace engineering controls to effectively reduce accident risk levels.

Table 2. Job Safety Analysis (JSA) for Spray Booth and Oven Operation

No	Job Step	Potential Hazard	Possible Impact	Control Measures
1	Material preparation	Chemical exposure, spills	Skin irritation, poisoning	Use gloves, masks; proper chemical handling
2	Spray painting	VOC inhalation, fire hazard	Respiratory issues, burns	Use respirator, improve ventilation, avoid ignition sources
3	Oven drying	High temperature, explosion	Burns, fatal injury	Use heat-resistant PPE; monitor temperature
4	Inspection process	Contact with hot surface	Minor burns	Allow cooling before handling
5	Cleaning	Chemical contact, slippery floor	Irritation, slips	Wear gloves, clean workspace properly

Based on the analysis in Table 2, the spray painting process is the most critical stage due to the presence of hazardous chemical exposure and fire risks. Using the risk matrix (L×S), the risk level is classified as moderate to high (R = 10–16). This finding supports Salam and Ikhsanudin (2025), who emphasized that chemical-based processes in laboratory environments present significant occupational hazards if not properly controlled.

The application of Job Safety Analysis (JSA) in this study provides a structured framework for identifying hazards at each work stage and developing appropriate control measures. Previous studies have shown that implementing JSA can significantly reduce workplace accidents by improving hazard awareness and preventive actions (Yasinta et al., 2025; Idaman et al., 2026). Therefore, the implementation of JSA combined with Fishbone Diagram analysis in this study successfully produced practical and safer work guidelines for spray booth and oven operations, contributing to the improvement of the Occupational Safety and Health Management System (OSHMS) in laboratory environments.

Discussion

The findings of this study demonstrate that the integration of Job Safety Analysis (JSA) and Fishbone Diagram is effective in identifying potential hazards and analyzing their root causes in spray booth and oven operations. The quantitative risk assessment using the risk matrix provides an objective basis for prioritizing hazards, while the qualitative Fishbone analysis reveals the underlying factors contributing to workplace risks.

The identification of human factors as the dominant cause of risk is consistent with previous studies, which indicate that unsafe behavior, lack of awareness, and insufficient training are major contributors to workplace accidents (Abiezzart & Marga, 2023; Yasinta et al., 2025). In this study, inconsistent use of PPE and low compliance with safety procedures significantly increased the likelihood of exposure to hazardous substances.

In addition, environmental factors such as poor ventilation and confined workspace were found to exacerbate the risks associated with chemical exposure. This finding supports Vikto (2021), who emphasized that inadequate environmental control systems can intensify occupational health risks, particularly in processes involving hazardous chemicals.

From a methodological perspective, the combined use of JSA and Fishbone Diagram provides a more comprehensive risk analysis compared to single-method approaches. JSA allows for detailed identification of hazards at each step of the work process, while Fishbone Diagram facilitates deeper understanding of causal relationships. This integrated approach aligns with Aziz (2025), who highlighted the importance of combining analytical methods to improve the effectiveness of risk management strategies.

The practical implications of this study suggest that improving occupational safety in laboratory environments requires not only technical interventions, such as upgrading ventilation systems, but also behavioral improvements through training and strict enforcement of safety procedures. Theoretically, this study reinforces the role of JSA and Fishbone Diagram as preventive tools that can be applied not only in industrial settings but also in educational laboratories.

Therefore, the findings of this study contribute to the development of a more effective and sustainable Occupational Safety and Health Management System (OSHMS), particularly in laboratory-based learning environments with high-risk activities.

CONCLUSION

Based on the results of this study, it can be concluded that the application of the Job Safety Analysis (JSA) and Fishbone Diagram methods is effective in identifying and analyzing Occupational Safety and Health (OSH) risks in spray booth and oven operations at the Automotive Engineering Laboratory of Universitas Negeri Makassar (UNM). The risk assessment using a risk matrix shows that most potential hazards are categorized as moderate risk (R = 10–12), while the highest risk level is found in the spray painting process (R = 16), particularly due to exposure to volatile organic compounds (VOC). These risk conditions are mainly influenced by chemical exposure, inadequate ventilation systems, and inconsistent use of personal protective equipment (PPE), which reaches approximately 70% compliance.

Through root cause analysis using the Fishbone Diagram, it was identified that human and environmental factors are the dominant contributors to occupational hazards. Human factors include low safety awareness, inconsistent PPE usage, and insufficient training, while environmental factors include poor air circulation, limited workspace, and accumulation of hazardous fumes. These conditions significantly increase the risk of respiratory disorders, burns, and potential fire or explosion incidents. The integration of JSA and Fishbone Diagram provides a comprehensive framework that enables hazard identification at each work stage and systematic tracing of root causes, resulting in more structured and applicable risk control recommendations based on the OSH hierarchy of controls.

The findings also confirm that the combined use of JSA and Fishbone Diagram is not only effective as an analytical tool for identifying hazards but also serves as a preventive approach in strengthening occupational safety management systems in laboratory environments. When consistently applied, this integrative method supports the development of technical, administrative, and behavioral control strategies that can significantly reduce occupational risk levels.

In line with these findings, it is recommended that laboratory management strengthen safety training programs to improve operator awareness of hazards associated with spray booth and oven operations. Strict enforcement of PPE usage should be implemented alongside improvements in ventilation systems and workplace layout to reduce exposure to hazardous substances. Regular monitoring and evaluation of OSH implementation are also necessary to ensure continuous compliance with safety standards. Future research is recommended to expand risk assessment approaches by integrating more advanced methods such as HIRARC, FMEA, or HAZOP, as well as considering ergonomic and environmental exposure factors to achieve a more comprehensive risk evaluation.

In conclusion, this study emphasizes that a systematic, integrative, and evidence-based OSH risk management approach is essential to improve workplace safety performance in vocational laboratory environments, particularly in high-risk technical activities involving chemical and thermal processes.

REFERENCES

Abiezzart, M. D., & Marga, H. (2023). *Pelaksanaan program keselamatan dan kesehatan kerja di PT Perusahaan Gas Negara (Persero) Tbk*. Universitas Lampung Repository. https://digilib.unila.ac.id/69218/

Afrizal, M. D. (2023). *Analysis of occupational health and safety in spray booth room*. Universitas Islam Indonesia Repository. https://dspace.uii.ac.id/handle/123456789/45618/

Anggraeni, S. F. A. (2025). *Identifikasi dan pengendalian risiko keselamatan dan kesehatan kerja menggunakan metode HIRARC dan FMEA*. Universitas Islam Indonesia Repository. https://dspace.uii.ac.id/handle/123456789/58510/

Anitasari, M. E., & Widiyatmoko, W. (2025). *Keselamatan dan kesehatan kerja pada praktik sistem otomotif*. Jurnal Pendidikan Vokasi Otomotif. http://jurnal.uny.ac.id/index.php/jpvo/article/view/90466

Aziz, F. U. D. (2025). *Evaluasi risiko keselamatan dan kesehatan kerja menggunakan metode JSA dan fishbone*. Universitas Setia Budi Repository. https://eprints.setiabudi.ac.id/id/eprint/92/

Faizah, I., & Nadroh, U. (2025). *Analisis potensi bahaya sistem K3 menggunakan metode Job Safety Analysis pada bengkel otomotif*. Jurnal Kesehatan Masyarakat. http://jurnal.uinsu.ac.id/index.php/kesmas/article/view/22298/

Hansabila, P. (2023). *Analisis pengendalian risiko K3 menggunakan metode HIRARC*. Universitas Islam Indonesia Repository. https://dspace.uii.ac.id/handle/123456789/47126/

Idaman, R. P., Jufriyanto, M., & Priyana, E. D. (2026). *Evaluasi risiko kecelakaan kerja menggunakan metode HIRARC dan JSA*. Jurnal Teknologi Industri. https://jurnal-tmit.com/index.php/home/article/view/1478

Junita, R., Santi, T. D., & Ariscasari, P. (2025). *Analisis risiko keselamatan kerja menggunakan metode HIRADC*. Jurnal Penelitian Inovatif. https://www.jurnal-id.com/index.php/jupin/article/view/1326

Rosanti, V. D. R. N. (2024). *Faktor dominan kecelakaan kerja di industri manufaktur*. Universitas Muhammadiyah Gresik Repository. https://eprints.umg.ac.id/9401/

Salam, R. S., & Ikhsanudin, I. (2025). *Analisis risiko kerja di lingkungan laboratorium menggunakan metode HIRARC*. Journal of Future Education. http://journal.tofedu.or.id/index.php/journal/article/view/522/

Vikto, A. W. (2021). *Hubungan paparan bahan kimia terhadap kesehatan pekerja bengkel*. UIN Raden Intan Repository. https://repository.radenintan.ac.id/15829/

Yasinta, R. B., Ahmad, F., & Darmawan, A. (2025). *Analisis risiko kecelakaan kerja menggunakan metode JSA dan HIRA*. Jurnal Teknik Industri. https://journal.unesa.ac.id/index.php/proteksi/article/view/43286/

Yulistio, C. (2023). *Analisis penerapan metode Job Safety Analysis dan Fishbone Diagram dalam pengendalian risiko kerja*. Universitas Islam Indonesia Repository. https://dspace.uii.ac.id/handle/123456789/48356/