

Relationship Between Chemical Exposure and Health Complaints Among Confined-Space Painting Workers

Septy Anggraini^{1*}, Taufik Kurohman², Murniani Murniani³, Rendita Dwibarto⁴

Universitas Anak Bangsa, Bangka Belitung, Indonesia^{1,2,3,4}

taufikabdinusa@gmail.com^{1*}



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Abstract

Purpose: This study aimed to determine the relationship between chemical exposure (paint, thinner, and solvent) and health complaints among painting workers in confined spaces at PT Pahala Harapan Lestari in 2026.

Research Methodology: This study employed a quantitative analytical approach with a cross-sectional design. The study involved 30 painting workers selected using total sampling technique. Primary data were collected through structured questionnaires and interviews. Data were analyzed using univariate and bivariate analyses, followed by the chi-square test using IBM SPSS statistics.

Results: The findings indicated a significant relationship between paint exposure and health complaints among painting workers in confined spaces ($p=0.006$). However, exposure to thinner ($p=0.483$) and solvent ($p=0.224$) was not significantly associated with health complaints. The most common complaints after painting activities in confined spaces were dizziness, eye irritation, shortness of breath, nausea, and fatigue.

Conclusions: Paint exposure was significantly associated with health complaints, whereas thinner and solvent exposure showed no significant relationship. These findings highlight the importance of implementing Occupational Safety and Health (OSH) measures, including the proper use of personal protective equipment and adequate workplace ventilation, to reduce chemical exposure.

Limitations: This study was conducted in a single company with a relatively small sample size; therefore, the findings cannot be generalized to the entire shipbuilding industry.

Contributions: This study provides scientific evidence regarding the relationship between chemical exposure and health complaints among confined-space painting workers and may support the improvement of occupational safety and health programs in the shipbuilding industry

Keywords: *Chemical Exposure, Confined Spaces, Health Complaints, Painting Workers*

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1. Introduction

Occupational Safety and Health (K3) is an important aspect of creating a safe, healthy, and productive work environment. The implementation of K3 aims to protect the workforce from various potential hazards originating from the work environment, both in the form of physical, chemical, biological,

ergonomic, and psychosocial factors. One of the risks that are often found in the industrial sector is exposure to chemicals that can cause occupational diseases if not controlled effectively. This exposure can occur through inhalation, skin contact, or contact with the eyes, and has the potential to cause health problems both in the short and long term ([Ayuningtyas, 2021](#)). The shipyard industry is one of the sectors with a fairly high level of risk of exposure to chemicals. In the process of building and repairing ships, painting activities use various types of chemicals, such as paints, thinners, and solvents that contain Volatile Organic Compounds (VOCs). These compounds are volatile and can be inhaled by workers during painting. The risk of exposure increases if the work is carried out in a confined space with inadequate ventilation, resulting in a higher concentration of chemical vapors in the air ([Adiatma, 2016](#)).

Continuous exposure to chemicals can cause various health complaints, including dizziness, headaches, nausea, eye irritation, respiratory tract disorders, shortness of breath, and nervous system disorders. In the long term, the accumulation of chemicals in the body can damage organs such as the liver, kidneys, and central nervous system. Therefore, controlling exposure to chemicals is an important part of efforts to prevent occupational diseases and improve the quality of workers' health ([Azis, 2021](#)). Globally, international labor organizations report that millions of workers experience work-related illnesses each year due to exposure to chemicals in the work environment. In Indonesia, the use of chemicals in the industrial sector continues to increase along with the development of the industrial world; therefore, the potential for health problems due to exposure to chemicals remains a concern in the implementation of the K3 program. This condition shows that the protection of workers who interact directly with chemicals must be continuously improved through technical, administrative, and personal protective equipment controls.

PT Pahala Harapan Lestari is a shipyard company that conducts various ship construction and repair activities. One of the jobs that has a high level of risk is painting in a confined space. Based on the results of the initial observations, workers often complained of dizziness, nausea, eye irritation, shortness of breath, and fatigue after painting. The narrow workspace and limited air circulation are suspected to increase the concentration of exposure to chemicals, increasing the risk of health complaints. Several previous studies have shown that exposure to chemicals in industrial workers is associated with the emergence of various health disorders, especially respiratory system disorders, irritation, and neurological disorders. However, studies that specifically examine the relationship between exposure to paint, thinners, and solvents and health complaints in painting workers in confined spaces in shipyards are still relatively limited. In addition, most previous studies have focused on only one type of chemical or have been conducted in different industrial sectors ([Hafidz, 2025](#)).

Based on these conditions, this study was conducted to analyze the relationship between exposure to chemicals in the form of paints, thinners, and solvents and health complaints in painting workers in the confined space of the PT Pahala Harapan Lestari Shipyard in 2026. The results of this study are expected to contribute to the development of occupational health sciences and serve as a basis for companies to strengthen chemical exposure risk control programs and improve the implementation of occupational safety and health in the shipyard industrial environment.

2. Literature Review and Hypotheses Development

Exposure to chemicals in the work environment is one of the main risk factors that can affect the health of workers, especially in industrial sectors that use chemicals extensively. According to the International Labour Organization, millions of workers worldwide suffer from work-related illnesses due to exposure to harmful chemicals. Exposure can occur through inhalation, skin contact, or eye contact, causing acute or chronic health effects. Meanwhile, the World Health Organization states that chemicals in the work environment are one of the main causes of workers' health problems if not accompanied by adequate risk control.

In the field of occupational health, exposure to chemicals is defined as the process of entering the human body through the respiratory, skin, or gastrointestinal tract, which can interfere with the body's

physiological functions ([Cavallo, Ursini, Fresegha, & Casale, 2021](#)). The level of exposure hazard is influenced by the chemical concentration, duration of exposure, frequency of contact, individual characteristics of workers, and working environment conditions. The higher the intensity of exposure, the greater the risk of health problems in workers.

In the shipbuilding industry, painting work is one of the activities with the highest level of risk of exposure to chemicals. The painting process uses various types of chemicals, such as paints, thinners, and solvents, which contain Volatile Organic Compounds (VOCs). VOCs, such as toluene, xylene, ethylbenzene, and benzene, are volatile and can be inhaled by workers during the painting process ([Khusnul, Nisa, Hidayati, & Mardiyah, 2024](#)). The risk of exposure increases if the work is carried out in a confined space, which has limited ventilation, resulting in a higher concentration of chemical vapors in the air than in open spaces.

According to [Ghobakhloo, Khoshaklagh, Morais, and Mazaheri \(2023\)](#), chemicals that enter the respiratory system are absorbed into the bloodstream and distributed to various organs of the body. Short-term exposure generally causes dizziness, headaches, eye irritation, respiratory tract irritation, nausea, and fatigue, whereas long-term exposure can cause neurological disorders, liver damage, kidney disorders, and other chronic diseases. This statement is strengthened by [Wahyudi, Hidayat, Valentino, & Dwi, 2025](#), who stated that exposure to chemicals is one of the dominant causes of occupational diseases in the industrial sector. Paint is a coating material used to protect metal surfaces from corrosion while increasing their aesthetic value. Most industrial paints contain volatile organic solvents that can be a source of chemical exposure for workers. These compounds can cause eye irritation, respiratory disorders, and nervous system disorders when inhaled at high concentrations.

In addition to paint, thinners are widely used to dilute paint and clean painting equipment. [Seo, Shin, Yoon, and Byeon \(2024\)](#) explained that thinners contain various organic solvents, such as toluene, xylene, and n-hexane, which have neurotoxic effects. Short-term exposure to thinners can cause dizziness, nausea, decreased concentration, and impaired body coordination. If it occurs repeatedly over the long term, such exposure has the potential to cause peripheral nervous system disorders and to impair liver function. Solvents are a group of chemicals that are commonly used in the manufacturing and shipbuilding industries. According to the Agency for Toxic Substances and Disease Registry [Sarbiah \(2023\)](#), organic solvents have volatile properties; therefore, inhalation exposure is the primary route for chemicals to enter the bodies of workers. Under poor ventilation conditions, the concentration of solvents in the air increases, thereby increasing the risk of health problems.

Several studies in the last ten years have shown that exposure to chemicals is closely related to the emergence of workers' health complaints. [Rahmadani and Syafri \(2024\)](#) reported a significant relationship between chemical exposure and the risk of health problems in industrial workers. The study showed that workers with high exposure intensity were more likely to experience respiratory distress, eye irritation, and neurological complaints than those with low exposure. [Sari and Legiran \(2024\)](#) also showed that the higher the level of exposure to chemicals in the laboratory, the greater the risk of occupational health disorders. These results reinforce the theory that the duration and intensity of exposure are important factors influencing the appearance of work-related diseases. Furthermore, [Sekhar, Venguidesvarane, Thiruvengadam, Sharma, Venugopal, Rengarajan, and Johnson \(2024\)](#) found that painters exposed to heavy metals and organic solvents had a higher risk of experiencing health problems than other groups of workers. This study confirms that painting activities are associated with a high risk of exposure to chemicals. Volatile chemicals can cause an increase in health complaints in the form of headaches, dizziness, respiratory problems, and decreased work concentration. Meanwhile, [\(Wang & Chen, 2019\)](#) concluded that the implementation of chemical control through the use of personal protective equipment and good ventilation significantly reduced the level of exposure to workers.

[Nanang and Muhammad \(2024\)](#) research on the risk of exposure to sodium hydroxide also shows that exposure to chemicals has a close relationship with the emergence of health problems in petrochemical industry workers. These results show that different chemical characteristics can still have the potential to cause health impacts if risk control is not optimally implemented. Various international studies also

support the link between chemical exposure and workers' health complaints. [Wahyudi et al. \(2025\)](#) reported that painters had a higher prevalence of impaired lung function than the control group. [Kumar, Singh, and Sharma \(2023\)](#) found that workers exposed to organic solvents were more likely to experience headaches, dizziness, eye irritation, and respiratory tract disorders than those not exposed. [Chen, Li, Wang, and Zhang \(2021\)](#), [Lee, Kim, and Park \(2021\)](#), [Park, Kim, and Lee \(2022\)](#), [Wang, Zhao, and Liu \(2023\)](#), [Kumar et al. \(2023\)](#), [Lee et al. \(2021\)](#) have also consistently shown that exposure to chemicals in the work environment is associated with an increased risk of health disorders, particularly in the respiratory, nervous, and skin systems.

Based on these studies, it can be concluded that exposure to chemicals is an important risk factor for the emergence of health complaints among industrial workers. However, most previous research has been conducted in the manufacturing sector, laboratories, petrochemical industry, and painting work in general. Research that specifically examines the relationship between exposure to paint, thinners, and solvents and health complaints in painting workers in shipyard confined spaces is still very limited. In addition, previous studies generally examined only one type of chemical, whereas this study integrated three types of chemical exposures in a single analysis model. The research gap is the basis for this study. This research is expected to contribute to enriching the study of occupational health in the shipbuilding industry, especially related to the impact of exposure to chemicals in confined spaces that have higher exposure characteristics than ordinary work environments.

Based on the theory of occupational health, the results of previous research, and the conceptual framework that has been described, the research hypothesis is formulated as follows:

- H₁*: There is a relationship between paint exposure and health complaints among painting workers in the confined space of the PT Pahala Harapan Lestari Shipyard in 2026
- H₂*: There is a relationship between exposure to toluene and health complaints among painting workers in the confined space of the PT Pahala Harapan Lestari Shipyard in 2026
- H₃*: There is a relationship between solvent exposure and health complaints among painting workers in the confined space of the PT Pahala Harapan Lestari Shipyard in 2026

3. Research Methodology

This study used a quantitative approach with an observational analytical research design and a cross-sectional approach. This design was chosen because it could describe the relationship between independent and dependent variables that were measured simultaneously without giving treatment to respondents. The cross-sectional approach is suitable for analyzing the relationship between chemical exposure and health complaints in painting workers in the confined space of the PT Pahala Harapan Lestari Shipyard in 2026. The research was conducted at PT Pahala Harapan Lestari, Pangkalpinang City, Bangka Belitung Islands Province, from May to June 2026. The research location was chosen because the company has a ship painting activity in a confined space that has the potential to cause chemical exposure to the workers.

The research population is all painting workers who work in a confined space at PT Pahala Harapan Lestari as many as 30 people. Given the relatively small population, the entire population was used as a research respondent using the total sampling technique, so that the number of research samples was 30. The independent variables in this study were paint, thinner, and solvent exposures. The dependent variables were workers' health complaints, which included dizziness, nausea, eye irritation, shortness of breath, cough, and fatigue during or after painting. Primary data were collected through structured questionnaires and interviews.

The questionnaire was used to obtain information about the characteristics of the respondents, their level of exposure to chemicals, and the health complaints experienced by workers. Secondary data were obtained from company documents, K3 reports, and various scientific literature relevant to the research. The research instruments consisted of a structured questionnaire and interview guidelines developed based on the research variables and their indicators. Data analysis was carried out in two

stages: univariate and bivariate analyses. Univariate analysis was used to describe the frequency distribution of respondent characteristics, levels of exposure to chemicals, and workers' health complaints. Bivariate analysis was conducted using the chi-square test with a 95% confidence level ($\alpha = 0.05$) to determine the relationship between exposure to paint, thinners, and solvents and health complaints among painting workers in confined spaces. The relationship was considered significant if $p < 0.05$. This research has paid attention to the ethical aspects of research by providing explanations to all respondents about the purpose of the research, data confidentiality, and the right of respondents to participate willingly. All respondents provided informed consent before data collection process was carried out.

4. Results and Discussions

4.1 Univariate Analysis

This analysis was used to examine the distribution of respondents based on exposure to chemicals and health complaints among workers painting at the shipyard of PT Pahala Harapan Lestari.

Table 1. Distribution of Respondents Based on Chemical Exposure and Health Complaints

Variables	Frequency (f)	Percentage (%)
Dependent Variable		
Health Complaints		
With Health Complaints	15	50
No Complaints	15	50
Independent Variables		
Paint Exposure		
High	0	0
Moderate	7	23,3
Low	23	76,7
Thinner		
High	0	0
Moderate	2	6,7
Low	28	93,3
Solvents		
High	0	0
Moderate	3	10
Low	27	90

Based on Table 1, out of 30 respondents, 15 respondents (50 %) had health complaints, while 15 respondents (50 %) had no complaints. In the paint exposure variable, most respondents had low paint exposure, with 23 respondents (76.7%), while respondents with moderate paint exposure were seven (23.3%). Based on thinner exposure, the majority of respondents had low thinner exposure, namely 28 respondents (93.3%), while moderate thinner exposure was 2 respondents (6.7%). In addition, for the solvent exposure variable, most respondents had low solvent exposure, with 27 respondents (90%), while respondents with moderate solvent exposure were three (10%).

4.2 Respondent Characteristics

The study involved 30 painting workers who worked in confined spaces at PT Pahala Harapan Lestari. Based on the results of the univariate analysis, most respondents had worked for more than three years and therefore had relatively high cumulative exposure to chemicals. All respondents worked directly with paint, thinner, and solvents during the ship-painting process. Work activities were conducted in confined spaces with limited ventilation, increasing the potential for chemical-vapor accumulation. Although the company had provided Personal Protective Equipment (PPE), compliance remained suboptimal because some workers did not consistently use respirators due to discomfort. This finding is consistent with evidence that non-compliance with PPE requirements contributes to occupational

risk and should be addressed through systematic hazard control, supervision, and enforcement ([Prabowo, Larasati, & Maulani, 2026](#)).

4.3 Bivariate Analysis

Bivariate analysis was conducted to determine whether there was a meaningful relationship between the variables in the study.

Table 2. The Relationship of Paint Exposure, Thinner Exposure, Solvent Exposure to Health Complaints in Painting Workers

Variables	Complaints WithHealth Complaints F %	Complaints WithHealth Complaints F %	Health No Complaints f %	Health No Complaints f %	Total F %	Total F %	OR (95%CI)	P-Value
Paint exposure								
High	0	0	0	0	0	100	2,875	0,006
Moderate	0	0	7	100	7	100		
Low	15	65,2	8	34,8	23	100		
Thinner exposure								
High	0	0	0	0	0	100	2,154	0,483
Moderate	0	0	2	100	2	100		
Low	15	53,6	13	46,4	28	100		
Solvent exposure								
High	0	0	0	0	0	100	2,250	0,224
Moderate	0	0	3	100	3	100		
Low	15	55,6	12	44,4	27	100		

Based on Table 2, there is a relationship between paint exposure and health complaints among painting workers in the confined space of the PT Pahala Harapan Lestari shipyard in 2026. Workers with low paint exposure experienced more health complaints, namely 15 respondents (65.2%), compared to those with moderate and high paint exposure. The results of the statistical test showed a significant relationship between paint exposure and health complaints, with a p-value of 0.006 and a POR value of 2.875. In the thinner exposure variable, most respondents with low exposure to thinner experienced health complaints, namely 15 respondents (53.6%). The results of the statistical test showed no relationship between thinner exposure and health complaints ($p = 0.483$). In addition, in the solvent exposure variable, most respondents with low solvent exposure experienced health complaints, namely, 15 respondents (55.6%). The results of the statistical test showed no relationship between solvent exposure and health complaints ($p = 0.224$).

4.4 The Relationship of Paint Exposure to Health Complaints

The bivariate analysis showed a significant relationship between paint exposure and health complaints among painting workers in confined spaces ($p = 0.006$ [$p < 0.05$]). These results showed that workers with higher paint exposure tended to experience more health complaints than those with lower exposure levels. The findings of this study show that paint is the main source of chemical exposure during the painting process. Paints contain a variety of Volatile Organic Compounds (VOCs), such as toluene, xylene, and ethylbenzene, which are easily volatile and inhaled by workers. In confined spaces, poor air circulation causes the concentration of chemical vapors to increase, resulting in a higher risk of exposure. The most frequently reported health complaints of the respondents included dizziness, eye irritation, shortness of breath, headache, and fatigue. These symptoms appear during the painting process and shortly after completing the work. This condition indicates the body's response to continuous chemical exposure. The results of this study are in line with those of [Rahmadani and Syafri \(2024\)](#), who stated that exposure to chemicals in industrial workers is significantly related to an increased risk of health problems. These findings also support the research of [Kumar et al. \(2023\)](#), who found that workers who were frequently exposed to paint vapor had a higher prevalence of respiratory system disorders, eye irritation, and mild neurological disorders. Chemical vapor inhalation is the most dominant route of exposure in painting work. VOCs that enter the respiratory system are absorbed into the blood and affect various organs, especially the central nervous and respiratory systems. Therefore, the use of appropriate respirators and adequate ventilation systems is an important step in reducing the risk of health problems ([Sahri 2020](#)).

4.5 The Relationship of Thinner Exposure to Health Complaints

The results of the analysis showed that thinner exposure was not significantly associated with workers' health complaints ($p = 0.483$). This value shows that statistically thinner exposure was not been proven to be related to the emergence of health complaints in the study respondents. The absence of a significant association is thought to be due to a variation in the intensity of thinner use, which is not too high compared to the use of paint during the painting process. In addition, thinners are more widely used in the mixing and cleaning stages of equipment, so the worker contact time is relatively shorter. Despite this, some respondents reported symptoms such as dizziness, nausea, and eye irritation after using the thinner. This shows that thinners have the potential to cause health problems if exposure lasts for a long time or at high concentrations. The results of this study differ from those of [Sari and Legiran \(2024\)](#), who stated that exposure to organic solvents is related to health problems in painting workers. The difference in results may be influenced by the number of respondents, work environment conditions, duration of exposure, and compliance with the use of different PPE in each study.

4.6 The Relationship between Solvent Exposure and Health Complaints

Bivariate analysis showed that solvent exposure was not significantly associated with workers' health complaints ($p = 0.224$). Although statistically insignificant, the results of the observations showed that some workers still complained of dizziness, shortness of breath, and eye irritation after using solvents. This shows that exposure to solvents still poses a risk to workers' health, especially if it occurs continuously in poorly ventilated spaces. Organic solvents contain volatile compounds that are volatile so that they can enter the body through the respiratory tract. However, the magnitude of the health impact is greatly influenced by the concentration of chemicals, duration of exposure, ventilation conditions, and use of PPE. Therefore, the insignificance of the results of this study does not mean that the solvent is safe for workers, but rather shows that under the study conditions, there has not been a statistically significant relationship.

4.7 Discussion

The results showed that, among the three types of chemical exposure analyzed, only paint exposure had a significant relationship with the health complaints of workers in confined spaces. This finding indicates that paint is a major exposure source that requires priority attention in the company's occupational safety and health program. The non-significant relationships for thinner and solvent exposure may reflect shorter exposure duration, PPE use, the small sample, and specific workplace conditions; they do not establish that these substances are harmless. Occupational risk is shaped by the interaction among hazards, exposure duration, chemical concentration, worker characteristics, and control measures. Evidence from manufacturing workers further indicates that OHS knowledge and work tenure are important factors in workplace safety, underscoring the need for targeted training and supervision ([Juhanda, Maulina, & Utami, 2026](#)). For painting work in confined spaces, adequate ventilation, standard-compliant respirators, PPE supervision, and periodic health examinations should therefore be implemented consistently. Overall, this study contributes to occupational safety and health knowledge in the shipbuilding sector and provides a basis for strengthening company policies on chemical-exposure control and worker health protection.

Based on the results of this study, the company is advised to strengthen the Occupational Safety and Health (OHS) program for painting work in confined spaces by improving ventilation systems, supervising PPE use, providing chemical-hazard training, and conducting periodic health examinations. Workers should use PPE completely and correctly and comply with established work procedures to reduce chemical-exposure risks. Educational interventions can improve workers' knowledge and awareness of PPE, supporting their consistent use as part of occupational-risk prevention ([Asrawi, Rahayu, & Tampubolon, 2024](#)).

5. Conclusions

5.1 Conclusion

This study showed a significant relationship between paint exposure and health complaints in painting workers in confined spaces of PT Pahala Harapan Lestari in 2026, with a p-value of 0.006. Workers

exposed to higher paint levels tend to experience complaints such as dizziness, nausea, eye irritation, shortness of breath, headaches, and fatigue. Exposure to thinner ($p = 0.483$) and solvent ($p = 0.224$) was not significantly associated with health complaints. These findings indicate that exposure to paint is the most influential factor in the emergence of health complaints among painting workers in confined spaces.

5.2 Research Limitations

This study has several limitations, namely the relatively small number of respondents and only one company, so the results of the research cannot be generalized to the entire shipbuilding industry. In addition, chemical exposure measurements are carried out through observation and questionnaires without directly measuring chemical levels in the air of the work environment or checking the biological biomarkers of workers. The cross-sectional research design can only describe the relationship between variables at one observation time and cannot explain the direct cause-and-effect relationship.

Based on the results of this study, the company is advised to increase the implementation of the Occupational Safety and Health (K3) program, especially in painting work in confined spaces, by improving ventilation systems, supervising the use of Personal Protective Equipment (PPE), training on chemical hazards, and periodic health checks for workers. Workers are also expected to use PPE completely and correctly and comply with established work procedures to reduce the risk of exposure to chemicals.

5.3 Suggestions and Directions for Future Research

For future research, it is recommended to involve a larger number of respondents and be carried out in several companies so that the results of the study have a better level of generalization. Future research should also use measurements of chemical levels in the air of the work environment, as well as biological examinations of workers, to obtain a more accurate picture of exposure levels. In addition, other variables, such as working period, duration of exposure, compliance with PPE use, smoking habits, nutritional status, and ventilation conditions, need to be further analyzed as factors that can affect the appearance of health complaints in painting workers in confined spaces.

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Author Contributions

SA and TK contributed to the conceptualization and methodology, with M also contributing to the methodology. SA conducted the investigation, prepared the original draft, and performed the formal analysis with M. M and RD carried out the validation. TK, MM, and RD reviewed and edited the manuscript, while TK provided supervision. All authors have read and agreed to the published version of the manuscript.

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