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Impact of OSH supervision and communication on workers safe behavior in the heavy-duty steel wheel rim industry

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Abstract

High-risk mechanical and ergonomic hazards necessitate strict occupational safety and health (OSH) practices to mitigate workplace accidents and promote worker welfare in the steel wheel rim industry. The study aims to analyze the impact of OSH supervision and communication on workers' safe behavior within the heavy steel rim sector. A total of 72 respondents participated in this research, with findings indicating that most respondents received good supervision (58 respondents) and exhibited safe behavior (60 respondents). Logistic regression analysis was employed to evaluate the relationship between safe behavior, supervision, and communication. Results demonstrate that good supervision nearly doubles the likelihood of safe behavior (OR = 1.97), while effective communication increases the probability of safe behavior more than fivefold (OR = 5.15). Although this model accounts for only 9.8% of the variation in safe behavior (Pseudo R-squared = 0.09821), these findings underscore the importance of effective communication and proactive supervision in fostering a safe work environment. It is recommended that companies prioritize these two factors to enhance worker safety.

Keywords: Communication, Heavy-duty steel industry, Logistic regression analysis, OSH supervision, safe behaviour.

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1. Introduction

Manufacturing industry, especially the heavy steel industry, such as the manufacture of steel wheels, is one of the sectors most vulnerable to the risk of work accidents and injuries due to a hazardous work environment. Work accidents not only impact the occupational health and safety (OSH) of workers but also have implications for the productivity and operational efficiency of the company. Therefore, effective OSH management is essential to reduce the risk of accidents and improve workers' safe behavior. As stated by the International Labour Organization (ILO), there are roughly 2.78 million deaths related to workplace accidents worldwide each year, with 270 million accidents and 160 million work-related illnesses reported annually [1]. Workplace accidents are often caused by a combination of factors, including unsafe working conditions, lack of safety training, and ineffective communication between management and workers [2]. In the steel industry, the risk of accidents is higher due to processes involving high temperatures, hazardous chemicals, and heavy equipment [3].

Data from the Indonesian Ministry of Manpower [4] records 221,740 cases of work accidents in the last 5 years, with the metal and machinery industry accounting for 18% of the total cases [5]. The steel wheel rim industry, which involves processes such as casting, welding, and heavy machining, is vulnerable to risks such as mechanical injury, exposure to metal dust, and noise. The Occupational Safety and Health Number 1 of 1970, then Law Number 13 of 2003 concerning Employment, has also emphasized the importance of implementing OSH standards in the workplace. However, the implementation of OSH in Indonesia still faces challenges such as limited supervision, low worker awareness, and ineffective communication between management and workers. Occupational safety and health (OSH) supervision and safety communication are key factors in shaping workers' safe behavior [6]. These dangers are connected to safety performance, which, in contrast, exists because of a lack of safety leadership, safety commitment, and safety communication [7, 8]. A secure work environment is fostered by the strong support and commitment to safety from both employees and employers. Several studies indicate that one important contributing issue is inadequate communication, which causes accidents [7-9]. Proactive supervision and routine inspections reduce violations of safety procedures in the German steel industry [10]. Two-way communication between supervisors and workers increases compliance with personal protective equipment (PPE) in Chinese manufacturing plants [11]. Another study revealed that workers in the metal industry feel that OSH supervision is a formality, and only a few receive adequate safety communication training [12]. These findings reveal a gap between global OSH theory and practice in the field, particularly in labor-intensive industries such as steel wheel rims.

Research on the effect of OSH supervision and communication on worker safety behavior in the heavy steel wheel industry is highly relevant to provide an empirical basis for the development of more effective OSH strategies in Indonesia. This research is expected to provide concrete recommendations for companies and policymakers to optimize OSH programs, reduce work accidents, and improve worker welfare. This research also aims to raise awareness of the importance of a working culture that prioritizes safety in the workplace and encourages innovation in monitoring and communication systems that are adaptive to the dynamics of heavy industry. OSH supervision and communication are the main pillars in building safe behavior in the workplace, and improving these two aspects can reduce the risk of work accidents and negative impacts on workers' health. Therefore, this research aims to analyze in depth the effect of OSH supervision and communication on the safe behavior of workers in the heavy steel wheel industry to produce findings that can be applied to enhance occupational safety and health in Indonesia's heavy industry sector.

2. Methods

2.1. Research Design

This research employed a cross-sectional survey design to investigate the impact of OSH supervision and safety communication on workers' safe behavior in the heavy-duty steel wheel rim industry. The study approach with a quantitative method was utilized to collect and analyze data, and analysis was applied to assess the relationship between the independent variables, OSH supervision and communication and the dependent variable, workers' safe behavior, with logistic regression.

2.2. Participants and Sampling

The target population for this study comprised employees working in the heavy-duty steel wheel rim industry. Technique sampling was used. A stratified random sampling technique was employed to select a representative sample from different job categories (e.g., production workers, maintenance staff, and supervisors) to ensure diverse perspectives on safety practices. The final sample consisted of 72 respondents, which provided sufficient power to detect significant relationships in the regression model.

2.3. Data Collection Procedure

The collected data was obtained using a questionnaire distributed both in paper format and electronically. Before data collection, the study protocol was approved by the institutional ethics committee, and informed consent was obtained from all participants. The questionnaire included items related to demographic characteristics, perceptions of OSH supervision, frequency and quality of safety communication, and self-reported safe behavior at work. Data collection was conducted over two months at several major manufacturing facilities within the industry.

2.4. Measurement Instruments and Data Analysis

All variables in this study were measured using a dichotomous measurement scale (yes/no), where participants only chose between two options: "Yes" (1) or "No" (0). This scale is used to assess actions or attitudes related to workplace safety procedures. Data analysis was conducted using SPSS version 25.0. Preliminary analysis involved descriptive statistics to summarize demographic variables and to assess the distribution of the key study variables. Cronbach's alpha was calculated to ensure the internal consistency of the scales used for OSH supervision and communication. For inferential analysis, binary logistic regression was employed to examine the impact of OSH supervision and communication on workers' safe behavior. The logistic regression model was specified in Equation 1:

$$logit\ (p) = \beta_0 + \beta_1(\text{OSH Supervision}) + \beta_2(\text{Communication}) \quad (1)$$

where p is the probability of workers exhibiting safe behavior. The regression coefficients (β) were estimated using the maximum likelihood method. Model fit was evaluated using the Hosmer-Lemeshow goodness-of-fit test, and the significance of individual predictors was assessed using Wald statistics with a significance level set at $p<0.05$. Multicollinearity among independent variables was checked using the Variance Inflation Factor (VIF) values to ensure they were within acceptable limits (VIF < 5).

3. Results

3.1. Characteristics of Respondents

This study involved 72 workers from the heavy steel wheel rim industry. The data collected showed that the majority of respondents (58 out of 72) received good supervision, while 14 respondents received poor supervision. In terms of safe behavior, the majority of respondents (60 respondents) demonstrated safe behavior, while only 12 respondents demonstrated unsafe behavior. In addition, good communication was recorded in 51 respondents, while 21 respondents experienced poor communication. The distribution of respondents based on research variables is presented in Table 1.

Table 1.
Distribution of respondents based on research variables.

Variables	Categories	Number of Respondents	Percentage
OSH Supervision	Good	58	80.6%
	Bad	14	19.4%
Communication	Good	51	70.8%
	Poor	21	29.2%
Safe Behavior	Safe	60	83.3%
	Not Safe	12	16.6%

From the table, it can be seen that the majority of respondents received good supervision (80.56%), and the majority also demonstrated safe behavior (83.33%). The same goes for good communication, which was recorded in 70.83% of respondents. This reflects a positive trend towards good supervision and effective communication in improving safe behavior in the work environment. However, there are around 16.67% of respondents who exhibit unsafe behavior, which indicates that factors other than supervision and communication may also influence employees' safe behavior.

3.2. Results of Binary Logistic Regression Analysis

The binary logistic regression model constructed the relationship analyzed between supervision, communication, and safe behavior produces the following coefficients: an intercept of -0.2916, a supervision coefficient of 0.6779, and a communication coefficient of 1.6399. The results of this analysis show that good communication and good supervision have a positive effect on the probability of safe behavior. This model has a Pseudo R-squared of 0.09821, which indicates that this model can explain about 9.8% of the variation in safe behavior. Table 2 summarizes the results of this study:

Table 2.
Results of binary logistic regression analysis.

Variables	Coefficient	Odds Ratio (OR)	Interpretation
Intercept	-0.2916	0.75	Basic log-odds for safe behavior when surveillance and communication are poor
OSH Supervision	0.6779	1.97	Good supervision almost doubles the chances of safe behavior.
Communication	1.6399	5.15	Good communication increases the chances of safe behavior more than fivefold.
Fit Model			Pseudo R-squared: 0.09821 (explains 9.8% of the variation in safe behavior).

Based on the results analysis, good supervision has an almost twofold greater chance of producing safe behavior (OR = 1.97), while good communication shows a greater influence with more than fivefold higher chances for safe behavior (OR = 5.15). Although this model only explains about 9.8% of the variation in safe behavior, these results emphasize that both factors, especially good communication, play a significant role in improving workers' safe behavior. This study suggests

focusing more efforts on improving the quality of communication in the workplace to strengthen the positive influence on work safety.

This analysis uses logistic regression to predict the probability of safe behavior based on two independent variables: supervision and communication. The two regression graphs above illustrate the relationship between each of these variables and the probability of safe behavior. Figure 1 shows how supervision (good vs. bad) affects the probability of safe behavior. The regression line (red) illustrates that when supervision goes from bad (0) to good (1), the probability of safe behavior increases significantly. This reflects that good supervision increases the chances of workers demonstrating safe behavior, with a higher probability when supervision is well administered.

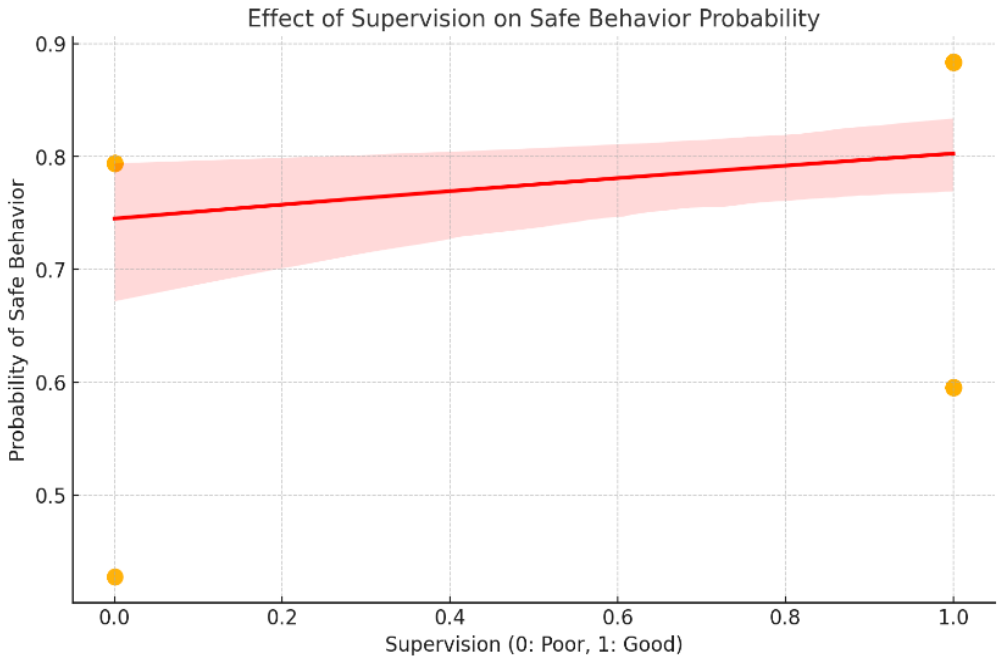

Figure 1.
Regression plot of the effect of supervision on the probability of safe behavior.

Figure 2 shows the influence of communication on the probability of safe behavior. The regression line (blue) shows that an increase in the quality of communication from poor (0) to good (1) causes a sharper increase in the probability of safe behavior. With a higher odds ratio of communication (5.15), good communication has a greater influence than supervision in increasing the probability of safe behavior. Both supervision and communication significantly impact safe behavior in the workplace, with communication having a more pronounced effect. These regression plots visually demonstrate how both factors increase the likelihood of workers engaging in safe practices, emphasizing the importance of improving communication to enhance workplace safety outcomes.

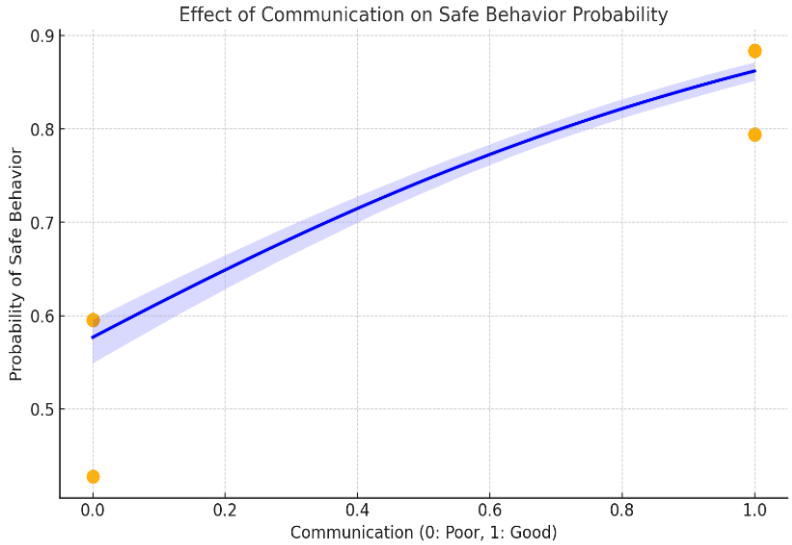

Figure 2.
Regression plot of the effect communication on the probability of safe behaviour

3.3. Prediction Of Safe Behavior Probability Based on Logit Equation

Based on the logistic regression analysis model, the calculation of the probability of safe behavior in each respondent is constructed, depending on the status of supervision and communication that the respondent receives. The binary logistic regression model used to predict the probability of safe behavior employs the formula in Equation 1. Based on this formula, the log-odds can be calculated first for each respondent based on the status of supervision and communication, then the probability of safe behavior can be calculated using the logistic function the Equation 2:

$$P(\text{Safe Behaviour}) = \frac{1}{1+e^{-Logit}} \quad (2)$$

Where e is the natural logarithm base. Table 3 shows the predicted probability of safe behavior based on different combinations of supervision and communication:

Table 3.
Predicted probability of safe behavior based on different combinations.

OSH Supervision	Communication	Probability of Safe Behavior
Bad (0)	Poor (0)	42.76%
Bad (0)	Good (1)	79.39%
Good (1)	Poor (0)	59.54%
Good (1)	Good (1)	88.35%

The probability of safe behavior is relatively low at 42.76% when both supervision and communication are poor; workers are less likely to engage in safe behavior. The probability increases to 79.39% even when supervision is poor, indicating that good communication significantly improves the likelihood of safe behavior. With good supervision, the probability of safe behavior increases to 59.54%. This demonstrates that supervision plays a crucial role in promoting safe behavior, even if communication is lacking. The probability reaches the highest at 88.35%. This combination strongly supports safe behavior, highlighting the importance of both good supervision and effective communication in fostering a safe working environment.

4. Discussion

This study reveals that communication (OR = 5.15) has a stronger influence than OSH supervision (OR = 1.97) in shaping workers' safe behavior in the steel wheel rim industry. These findings are in line with the study by Griffin and Neal [13], which emphasizes that two-way communication is a critical issue of the safety climate, as it facilitates the exchange of risk information and direct feedback [13]. The dominance of communication in this study is also supported by Cahill et al. [14] who found that dialog-based safety training increased PPE compliance in the healthcare staff during COVID-19 [14]. However, the low Pseudo R-squared value (0.098) indicates that 90.2% of the variation in safe behavior has not been explained by the model, hinting at the role of other factors such as organizational culture, production pressure, or transformational leadership [15]. Effective OSH communication between supervisors and workers has been recognized as a main factor in improving workplace safety. Previous research has shown that open and regular communication between management and employees can influence the safety climate and safe behavior of workers [16]. Communication effectiveness in safety communication refers to the degree to which safety information is communicated accurately, clearly, and on time to all relevant stakeholders in the oil and gas industry. Effective safety communication ensures that workers are aware of safety hazards, understand safety procedures and regulations, and can take appropriate measures to prevent accidents and incidents. Communication effectiveness is crucial to the success of safety communication in the oil and gas industry. Effective safety communication ensures that safety information is accurately communicated to all relevant stakeholders, enabling workers to understand safety procedures and regulations, identify safety hazards, and take appropriate measures to prevent accidents and incidents [17-20]. In this study, the odds ratio (OR) of 5.15 indicates that employees with good OSH communication are 5.15 times more likely to demonstrate safety behavior compared to those with poor communication. This is consistent with the finding that effective communication facilitates a better understanding of safety procedures and increases employee participation in safety practices [21]. Organizations should monitor leading safety indicators and utilize appropriate tools and technology to identify and address safety issues proactively. By understanding and addressing factors such as communication climate, communication satisfaction, communication mechanisms, and safety commitment, organizations can improve safety performance and prevent accidents and injuries [2].

Although OSH supervision is significant (OR = 1.97), its effect is lower than communication. This reflects supervisory practices in heavy industries that tend to be reactive and checklist-based, rather than participatory. Effective supervision must combine routine monitoring with constructive feedback [22]. In Indonesia, 65% of workers consider OSH inspections to be a formality, thus reducing their impact on behaviour [23]. These findings reinforce the argument of Hale et al. [24] that supervision without dialogue only creates compliance without commitment [24]. Health and safety environment (HSE) vulnerability and lack of supervisor support independently increased the likelihood of physical injuries at the workplace. Compared to people without OSH vulnerability and with supportive direct supervisors, those who had both OSH vulnerability and a lack of supervisor support were at least 3.5 times more likely to experience physical harm. If they had a supportive boss, employees who were vulnerable were less vulnerable [21]. Supervisors who are proactive in identifying and addressing risks can create a safer work environment [25]. It is widely acknowledged in OSH literature that front-line supervisors influence workers' safety-related behaviors and their compliance with safety rules [21]. Establishing a safe work environment may be greatly aided by a supervisor who is cognizant of workplace dangers and safety issues. Improved

safety conditions and fewer injuries are thought to be significantly influenced by supervisors' awareness of OSH [21]. In addition, supervisors who are actively committed to safety and who proactively identify problems before they arise can have a meaningful impact on injury prevention and other positive safety outcomes [26]. Feedback from supervisors can provide unique insights into an organization's safety priorities. In a recent study, Huang et al. [27] it was discovered that there was a negative correlation between injury rates and safety performance, and a positive correlation between safety performance and supervisors' opinions of how effective their lines of communication are. Supervisors who are aware of the dangers and hazards in the workplace and who take proactive measures to shield employees from adverse health outcomes can lower the probability of harm in settings where employees report OSH vulnerability. Furthermore, a friendly and communicative safety atmosphere is facilitated by supervisors who actively prioritize and promote safety. For instance, a manager who promotes the use of personal protective equipment (PPE) may be a great help to employees who are at risk for occupational safety hazards.

Although supervision and communication have a significant impact on safe behavior, this model only explains 9.8% of the variation in safe behavior. This suggests that additional factors, including safety training, intrinsic worker motivation, and organizational safety culture, can also influence workers' safety behavior. Previous studies have emphasized that these factors, when combined with effective supervision and communication, can further enhance work safety [28, 29]. Therefore, companies should consider a more holistic approach to promoting safety, which includes ongoing safety education and the development of a strong safety culture [30].

The logistic regression model used in this study produced a Pseudo R-squared of 0.09821, which indicates that this model has a relatively low predictive ability. Pseudo R-squared is a measure used in logistic regression models to evaluate the extent to which the model explains variations in the data. This value shows that although this model is not fully capable of explaining variations in safe behavior, there is still a significant relationship between communication and supervision and the safe behavior of workers in the heavy steel wheel industry. Although the Pseudo R-squared result is not very high, these findings still provide important insights into the role of communication and supervision in improving work safety. Several previous studies have also shown that factors such as effective communication and good supervision have a positive impact on employees' safety behavior, although this cannot always be fully explained by predictive models [31-33]. According to previous studies, although the occupational safety model may show limited predictions, more in-depth factors such as the quality of communication and a proactive supervisory approach can directly influence workers' attitudes and behavior regarding safety [34]. Good supervision can increase compliance with safety procedures, while clear and open communication helps employees understand the importance of safety. Other studies also emphasize the importance of a communication-based approach in improving work safety [35]. Although compliance with safety procedures can be predicted by stronger models, good communication allows employees to better understand and accept applicable safety standards, which ultimately encourages them to become more actively involved in maintaining safety.

5. Conclusion

This study demonstrates that supervision and communication significantly influence workers' safe behavior in the heavy steel rim industry. Good supervision nearly doubles the likelihood of safe behavior (OR = 1.97), while effective communication increases it more than fivefold (OR = 5.15). Although the model accounts for only 9.8% of the variation in safe behavior (Pseudo R-squared = 0.09821), these findings highlight the critical role of effective communication and quality supervision in enhancing workplace safety within this industry. Occupational Safety and Health (OSH) interventions should prioritize two-way communication and participatory training approaches, rather than relying solely on formal inspections.

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