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Analysis of the Impact of PPE Implementation on Occupational Safety and Health on Construction (Case Study: 4-Storey Residential Building Project)

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Abstract. Project construction can be risky for workers if Personal Protective Equipment (PPE) is improper and correctly used. Complex construction projects are typically carried out in large cities like Surabaya. Usually, these projects involve contract workers with varying knowledge and awareness regarding PPE use. This study aims to analyze the level of work accident risk in a four-story house project undertaken by PT. Surya Andalan Bina Perkasa in Surabaya. The research method used was quantitative, with data collection techniques using questionnaires distributed to 30 samples. Data analysis techniques were carried out using simple linear regression and hypothesis testing. The study results show the risk level of work accidents in the four-story residential project carried out by PT. Surya Andalan Bina Perkasa is quite low. Types of work accidents with low risk include shortness of breath due to dust, head impacts, injuries from falls from heights, muscle and bone injuries caused by falling materials, hearing loss due to noise, and electric shocks. Types of risks in the low-medium category include irritation due to dust or wood shavings, minor foot injuries, hand injuries, body parts being struck by sharp objects, and accidents caused by heavy equipment. The level of worker compliance with PPE use is still low, as evidenced by 70% of workers being non-compliant and 30% being somewhat compliant in using PPE while working. The study results also show an impact of PPE implementation on occupational health and safety, evidenced by a correlation value of 24.9%. The significance of the hypothesis test is 0.005, and the determination value is 25.3%, indicating that the impact of PPE implementation on occupational health and safety is insignificant, as it only increases occupational health and safety by 25.3%.

Keywords: PPE, work accident risk, occupational health and safety

INTRODUCTION

Surabaya is one of the largest cities in Indonesia, with an area of 350.6 km2 and a total population in the 2022 population census of 2,880,000 people. With the data, the city of Surabaya is inseparable from various facilities and infrastructure to support all economic activities of the community, such as the construction of office buildings, the construction of hotels, the construction of residential houses, and other construction activities. The construction process of a construction project is generally an operation that involves many hazardous elements (Sinaga, 2021). Work accidents often occur when workers carry out project construction activities. The level of risk felt, ranging from mild to severe, is a special concern when implementing each of these activities.

Work safety during construction is an important indicator that affects the progress of construction (Jaya, 2021). The government expects contractors to be able to implement K3 on site fully. In reality, implementing K3 in the field is still less than optimal. Due to government requirements for implementing the Construction Safety Management System (SMKK), industrial accidents continue to occur and can result in losses and failure of construction projects.

Based on data from the Social Security Administering Agency (BPJS) for Employment, there were 370,747 accident cases in 2023. Around 93.83% were cases of wage-earning participants, and 5.37% were cases of non-wage-earning participants. Work accidents occur in various categories, ranging from minor accidents to serious/fatal accidents, but most of the categories with high death rates are industrial accidents in the construction industry.

The risk of work accidents does not only occur in large-scale construction projects. However, it can also occur in the construction of residential houses commonly carried out in the community. One of the construction projects that is quite risky is the construction of a four-story house carried out by PT—Surya Andalan Bina Perkasa in Surabaya with a budget of Rp 15,000,000,000 (fifteen billion). The project's construction is considered to have a high level of complexity compared to a one-story house project, so it is necessary to study the application of PPE in the project. The height of the building poses a risk of falling and makes it difficult for workers to access it. The construction of 4 floors also requires more complicated structural calculations, such as determining the load, materials, and appropriate construction techniques to ensure the stability of the building. Errors in design or execution can cause structural failure, so there is a risk of material collapse. If the work environment is not disciplined in using PPE, heavy equipment and electricity can cause serious work accidents for workers.

Therefore, researchers are interested in studying the application of PPE in a four-story house construction project and its impact on worker health and safety. This study is expected to describe how PT. Surya Andalan Bina Perkasa provides adequate PPE for all workers and supervises them strictly during the project. In addition, this study is also expected to show what obstacles workers experience when using PPE during the project.

METHODOLOGY

The research was conducted on the construction project of Mr. Kelvin's 4-story residential house, which was carried out by PT Surya Andalan and located on Jl. Darmahusada Indah Timur M8, Surabaya. The object of study was the impact of the PPE application system on occupational safety and health in construction projects. The approach and type of research used a quantitative approach, namely structured, formal, specific research, and had a detailed operational design where the data collection process was in the form of numbers. Some hypotheses were used as the basis for determining the direction of the research (Unardjan, 2019). Data analysis in quantitative research was also carried out based on statistics using extensive, random, accurate, and representative samples (Nurlan, 2019). Data was processed using SPSS software version 21 and Microsoft Excel 2019. Meanwhile, the study's data came from primary and secondary data obtained through questionnaires, interviews, observations, and documentation.

The population in this study included all workers involved in Mr. Kelvin's residential construction project, totaling 30 people. The sampling technique used was the saturated sampling method, which took the entire population as a sample. So, the number of samples is the same as the population, which is 30 people who are workers on the project. The method used in collecting data used questionnaires and field observations. The data analysis technique was carried out using simple linear regression tests and hypothesis tests.

RESULT AND DISCUSSION

The study results include data on worker characteristics, such as gender, age, position/job title, and work experience. Furthermore, the study's results also present observations of project workers' compliance with using PPE and data on the level of risk of the work carried out. Finally, the study results consist of worker response data regarding the impact of PPE implementation on occupational health and safety during the project. The data collection results show that the number of respondents in the research sample is 30 workers.

Worker characteristics data is divided into several categories, namely gender, age, position or job title, and work experience. The frequency of respondents according to worker characteristics is shown in Table 1.

TABLE 1. Respondent Characteristic Frequencies

Characteristics	Count	Percentage
Gender		
Male	29	96.7%
Female	1	3.3%
Total	30	100%
Years Old		
26 - 35	16	53.3%
36 - 45	11	36.7%

Characteristics	Count	Percentage
46 – 55	3	10.0%
Total	30	100%
Position		
Mason	8	26.6%
Helper	6	20.0%
Carpenter	9	30.0%
Foreman	7	23.3%
Total	30	1000%
Work Experience		
4-6 year	8	26..7%
7-10 year	10	33.3%
>10 year	12	40.0%
Total	30	100%

(**Source:** Data Analysis Results 2024)

The table above shows that respondents have differences in gender, age, position, and work experience.

The graph above shows that the application of PPE among workers in residential projects is still low because there are still more workers who are not compliant than those who are compliant in using PPE. Factors affecting workers' compliance with PPE are gender, age, type of work done, and work experience. To find out whether there is a relationship between gender, age, type of work done, and work experience with worker compliance, a crosstab analysis can be carried out, as shown in Table 2.

TABLE 2. Correlation Between Profile and Compliance Level

No.	Characteristics	Significant	Information
1.	Gender	0,506	Not related
2.	Age	0,008	Related
3.	Position	0,000	Related
4.	Work Experience	0,014	Related

(**Source:** Data Analysis Results 2024)

The table above shows that age, position, and work experience relate to worker compliance in using PPE. The higher the worker's age, the better their understanding of PPE. The higher the worker's position, the higher the implementation of PPE to be an example for other workers. The higher the worker's work experience, the better the level of compliance in using PPE.

The risks of work accidents on the work floor are low and medium. Types of work accidents with low risks are shortness of breath due to dust, impacts to the head, injuries due to falls from a height, muscle and bone disabilities due to being hit by material, hearing loss due to noise, and electric shock. The low risk of work accidents on the project's construction floor is due to the low probability of occurrence, even though the impact is high. For example, disabilities due to falling from a height have a dangerous impact but have a very low probability of occurring because workers are equipped with adequate equipment and PPE, so the risk score is low. Meanwhile, the medium to low category risks are irritation due to dust or sawdust, minor injuries to the feet, injured hands, body parts hit by sharp objects, and accidents due to heavy equipment. These work risks have an impact that is not too dangerous but has a high probability of occurring. For example, eye injuries or irritation due to sawdust dust have a less dangerous impact but are likely to occur often. Many carpenters are not disciplined in using PPE, so their work accident risk score is in the low-medium category.

The calculation of impact of the application of PPE (X) on the health and safety of workers in residential projects is calculated using simple regression, hypothesis, and determination tests. Before conducting the regression test, validity, reliability, and normality tests are carried out. The validity test is carried out using the Pearson Correlation technique with the help of SPSS version 21 software. The basis for making decisions on the validity test is if the rstatistics> rcritical; then the data is declared valid. The rcritical value is obtained from the r Product Moment table with the number of N in the table being 30-2 = 28 with a significance of 0.05 so that the rcritical value is 0.361. While the rstatistics value is obtained from data processing in SPSS, where the results can be seen in the following table:

TABLE 3. Validation Test Results

Variable	Symbol	$R_{critical}$	$R_{statistics}$	Description

Deployment PPE (X)	P1	0.361	0.873	Valid
	P2	0.361	0.865	Valid
	P3	0.361	0.652	Valid
	P4	0.361	0.723	Valid
	P5	0.361	0.890	Valid
	P6	0.361	0.875	Valid
	P7	0.361	0.917	Valid
Occupational Safety and Health (Y)	Q1	0.361	0.787	Valid
	Q2	0.361	0.742	Valid
	Q3	0.361	0.786	Valid
	Q4	0.361	0.507	Valid
	Q5	0.361	0.523	Valid
	Q6	0.361	0.822	Valid
	Q7	0.361	0.713	Valid

(**Source:** Data Analysis Results 2024)

The table above shows that each indicator of the variable question of the application of PPE (X) and the impact of occupational health and safety (Y) has a value of r count> r table so that all indicator items can be stated as valid. For example, variable Q1 with the statement 'I rarely experience work accidents when using PPE' has a value of r count 0.787> 0.361, so there is sufficient evidence to state that item Q1 is valid. The rstatistics value approaching 1 also indicates a very good correlation between indicators. Furthermore, a validity test is carried out on each indicator variable using the Cronbach's Alpha technique. If the Cronbach's Alpha value is > 0.60, then the data item can be stated as reliable. The results of the reliability test can be seen in the following table.

TABLE 4. Reliability test results

Variable	Indicator	Alpha Cronbach's
Deployment PPE (X)	Knowledge and attitude	0.785
	Deployment PPE (X)	0.869
Occupational Safety and Health (Y)	Impact of PPE on OSH	0.648
	Evaluation	0.600

(**Source:** Data Analysis Results 2024)

The table above shows that each indicator of X and Y variables has a Cronbach's Alpha value ≥ 0.600, which indicates that each indicator is reliable. For example, the knowledge and attitude indicator has a Cronbach's Alpha of 0.785> 0.6, so it is declared reliable, and further testing can be carried out.

The table above shows that each indicator of X and Y variables has a Cronbach's Alpha value ≥ 0.600, which indicates that each indicator is reliable. For example, the knowledge and attitude indicator have a Cronbach's Alpha of 0.785> 0.6, so it is declared reliable, and further testing can be carried out.

The table above shows that the R Square value is 0.253. This value indicates an increase in occupational health and safety of 25.3% after workers apply PPE correctly and with discipline. This strengthens the evidence of the impact of the use of PPE on the health and safety of residential project workers. Using disciplined PPE following established standards can reduce the risk of work accidents, especially for workers transporting heavy materials such as wood and stone that require head and foot protection to prevent the possibility of being hit by building materials. In addition, supervision of workers who are not disciplined in using PPE is also important, considering that using suitable PPE reduces the risk of accidents.

Discussion

Analysis of the Risk Level of Work Accidents in Residential Housing Projects

The risk level of work accidents in the 4-storey residential project carried out by PT. Surya Andalan Bina Perkasa is relatively high, as observed by 30 workers; all workers wore complete PPE to reduce the occurrence of work accidents that cause disability or reduced body function. Interview data with 30 workers showed that all carpenters and forepersons wore helmets, which helped prevent head injuries, while bricklayers wore boots that protected their feet from heavy objects. However, using PPE such as gloves, masks, and glasses was still inconsistent among workers. This shows that workers tend to avoid the risk of work accidents in heavy work only, such as the possibility of falling or being hit by heavy components. This means the risk of workers falling and being hit by heavy materials while working is relatively high compared to dust interference and the dangers of building material surfaces to the skin.

The type of work accident most often experienced by workers in the 4-story residential project is minor injuries to the feet, head, and hands. However, observations and interviews with workers showed that using PPE helped reduce the risk of minor injuries experienced by workers, as evidenced by the decrease in injury reports received by forepersons during the project. The foremen noted a decrease in the risk of minor accidents, indicating that PPE is important in creating a safer working environment for workers. However, some workers still need stricter supervision to ensure discipline in using PPE, especially among masons who are sometimes too lazy to use protective equipment.

In terms of health, using masks and goggles also effectively reduces respiratory problems and eye irritation due to dust generated during the project. This shows that the 4-story residential construction project also has a risk of respiratory problems and eye irritation due to the dusty and high-risk environment of the construction project. However, workers know that accidents are relatively low compared to the risk of falling or being hit by building materials. So, it can be said that workers know the importance of PPE in protecting their health during the project. Workers know that using masks helps reduce respiratory problems, and goggles reduce eye irritation from dust. The study results show that most workers consistently use PPE, thus reducing the risk of experiencing work accidents.

Based on the risk level score analysis, there is no high risk of work accidents in the residential construction project. There are only types of risks with low (R) and medium-low (MR) categories. Types of low-risk work accidents are shortness of breath due to dust, head impacts, injuries due to falling from a height, muscle and bone disabilities due to being hit by materials, hearing loss due to noise, and electric shock. The low risk of work accidents on the construction floor of a project is due to the low probability of occurrence, even though the impact is high. For example, a disability due to falling from a height has a dangerous impact. However, it has a very low probability of occurring because workers are equipped with adequate equipment and PPE, so the risk score is low. Meanwhile, the risks in the medium-low category are irritation due to dust or sawdust, minor injuries to the feet, injured hands, body parts hit by sharp objects, and accidents due to heavy equipment. These work risks have an impact that is not too dangerous but has a high probability of occurring. For example, eye injuries or irritation due to sawdust dust have a less dangerous impact but are likely to occur often. Many carpenters are not disciplined in using PPE, so the risk score for work accidents is in the medium-low category.

However, the study's results showed that compliance with applying PPE among workers was still low. Only 30% of workers were quite obedient in using PPE while working. At the same time, the other 70% were not obedient, especially carpenters and masons who had low compliance. Meanwhile, the risk of work accidents at the workstation has a significant impact, such as the possibility of being hit by heavy materials or sawdust that gets into the eyes. On average, carpenters and masons only use two types of PPE: helmets and shoes, helmets and gloves, or helmets and protective masks.

Impact Analysis of Profile on the Implementation of PPE on Residential Home Project Workers

The study results show that only age, position, and work experience affect worker compliance in using PPE on residential home projects. Age has a significance of 0.008, position has a significance of 0.000, and work experience has a significance of 0.014, indicating a relationship between age, position, and work experience with compliance in using PPE on the 4-storey residential home project being studied. Gender has no relationship with worker compliance because it only gives a significance of 0.506.

Workers aged 26-35 years have lower compliance in the use of PPE compared to workers aged 36-45 years and 46-55 years. Age affects worker compliance in using Personal Protective Equipment (PPE) due to various factors that

develop with age. One of the main factors is broader life experience. Older workers generally have more experience in the world of work, including experience facing dangerous situations or seeing firsthand the negative impacts of not complying with safety protocols. This experience increases workers' awareness of risk, so older workers tend to be more obedient in using PPE to protect themselves. In addition, older workers often have greater family responsibilities, such as being the primary breadwinner. The awareness that there is a family that depends on them causes workers to be obedient in using PPE.

Workers in the foreperson position are much more obedient to using PPE than masons and general assistants. Workers with the foreperson position show much more obedience than masons and general assistants. This is because the foreman's role and responsibility are more significant, making awareness of the importance of safety and self-protection in the workplace better. As a team leader, the foreman is also responsible for ensuring the safety of other workers, so he tends to be more disciplined in using PPE.

Workers with low work experience have low compliance in using PPE. The higher the work experience, the higher the level of compliance in using PPE. Workers with lower work experience tend to have lower compliance in using PPE, while workers with higher work experience show better compliance. More extended work experience provides a better understanding of the importance of workplace safety and the risks associated with not using PPE. Therefore, more experienced workers are more likely to comply with safety protocols and use PPE correctly.

The Impact of Implementing Personal Protective Equipment (PPE) on Occupational Health and Safety in Residential Housing Projects

Theoretically, the application of PPE impacts improving occupational health and safety. The results of the interview data also prove a decrease in reports of work injuries and increased discipline in the use of PPE by workers. To strengthen the study's results, statistical data processing was carried out to strengthen evidence of the impact of PPE on occupational health and safety in residential housing projects. The results of the descriptive statistical test show that the average age of workers is 25-45 years, which is a productive age. Workers should know the importance of implementing PPE in construction areas and be disciplined in wearing it. Workers working on residential housing projects also have an average of 4-20 years of work experience, so most workers are aware of the risk of work accidents experienced in construction areas. The correlation value between age and compliance with the use of PPE also shows a value of 0.008, which indicates that the older the worker, the higher his work experience.

The correlation test results with simple linear regression also show that using suitable PPE positively impacts occupational health and safety, with an increase of 24.9%. The hypothesis test results also show a significance value of 0.005, thus proving that the application of PPE impacts the health and safety of construction project workers. The better the application of PPE to workers, the health and safety of workers will increase by 25.3%. This shows that workers are aware of the importance of applying PPE to construction projects carried out and its impact on reducing the risk of work accidents.

The application of PPE impacts the health and safety of workers for several reasons. First, PPE, such as helmets, boots, and gloves, have effectively prevented physical injury. Helmets protect the head from impacts or falling heavy objects, boots protect the feet from sharp and heavy objects, and gloves protect the hands from injuries and irritation. Interview data shows that workers who consistently use PPE experience a decrease in minor injuries, indicating that this policy helps significantly reduce the risk of work accidents.

Second, the use of PPE also has a positive impact on workers' health. For example, masks and goggles help reduce respiratory problems and eye irritation from dust often found on construction sites. Workers who use masks report fewer respiratory problems, and workers who use goggles report less eye irritation. This shows that the PPE policy protects against physical injury and long-term health problems caused by exposure to dust and hazardous materials.

Furthermore, workers' positive perceptions of using PPE indicate that this policy has been well-received and considered important by workers. Most workers acknowledge that using PPE is essential for safety and health; some even emphasize the need for stricter supervision to ensure discipline in using PPE. This shows that the company's policy of implementing PPE has increased workers' awareness of the importance of occupational safety and health, creating a safer and healthier work environment.

Finally, the policy of using PPE also creates a workplace safety culture. With clear rules and strict supervision, workers become more disciplined and responsible in using PPE. This reduces the risk of accidents and health problems and increases work efficiency and productivity because workers feel safer and more protected. Thus, the company's policy regarding using PPE plays a key role in improving workers' occupational safety and health in residential construction projects.

CONCLUSION

The conclusion obtained from the study related to the application of PPE to occupational safety and health is the risk level of work accidents in the 4-story residential project carried out by PT. Surya Andalan Bina Perkasa is quite low. Types of work accidents with low risk are shortness of breath due to dust, impacts to the head, injuries from falling from a height, muscle and bone disabilities due to being hit by material, hearing loss due to noise, and electric shock. Types of risks in the medium-low category are irritation due to dust or sawdust, minor injuries to the feet, injured hands, parts of the body hit by sharp objects, and accidents due to heavy equipment. The level of worker compliance in the use of PPE is still low, as evidenced by 70% of workers who are not compliant and 30% who are pretty compliant in using PPE while working. The study also shows the impact of PPE on occupational health and safety, as evidenced by a correlation value of 24.9%. The significance value of the hypothesis test is 0.005, and the determination is 25.3%, which indicates that the implementation of PPE on occupational health and safety is not significant because it can only increase the value of occupational health and safety by 25.3%.

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