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Impact of PPE availability and safety training on occupational health implementation in rural construction projects: a cross-sectional study

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ABSTRACT

Introduction: The construction sector remains one of the most hazardous industries worldwide, with significantly higher rates of fatal and major injuries. In Indonesia, construction accidents contribute to a considerable proportion of national occupational incidents. This study evaluates the implementation of Occupational Health and Safety (OHS) programs in a rural water supply infrastructure project.

Method: A cross-sectional quantitative study was conducted involving 54 construction workers selected through total sampling. The study assessed Personal Protective Equipment (PPE) availability, PPE usage, and OHS training participation. Data were collected through structured interviews and direct observation. Statistical analysis was performed using the Chi-Square test with a significance level of 0.05.

Results: The study found significant associations between OHS program implementation and PPE availability ($p = 0.003$), PPE usage ($p = 0.001$), and OHS training ($p = 0.008$). Workers with complete PPE availability and proper usage and those who had received safety training demonstrated a higher adherence to OHS protocols.

Conclusion: The successful implementation of OHS programs in construction sites, particularly in rural water infrastructure projects, relies heavily on the availability and use of PPE and structured safety training. Strengthening these components can lead to a safer work environment and significantly reduce workplace accidents.

Keywords: Construction Workers, Occupational Health and Safety, Personal Protective Equipment, Rural Infrastructure, Safety Training.

INTRODUCTION

Occupational Health and Safety (OHS) is a fundamental aspect of labor protection that ensures the well-being of workers, particularly in high-risk sectors such as construction. Globally, the construction industry is recognized as one of the most hazardous sectors, accounting for a substantial proportion of occupational accidents and fatalities. According to the International Labour Organization (ILO), over 2.78 million work-related deaths occur annually, and construction is a leading contributor to this statistic (Van der Merwe *et al.*, 2025). The sector's dynamic nature, involving heavy machinery, hazardous materials, and exposure to environmental risks, makes it inherently dangerous and necessitates strict implementation of safety protocols. In Indonesia, construction-related incidents remain alarmingly frequent. Data from the Central Statistics Agency (BPS) in 2023 reported approximately 370,747 occupational accidents nationwide, with 2,965 incidents occurring within the construction sector (Harisah, 2023)

Construction activities in rural areas, such as developing clean water infrastructure, often receive limited oversight compared to urban projects (Sharma *et al.*, 2025). The scarcity of resources, lack of professional safety management, and insufficient training for workers increase the risk of accidents. Workers are frequently recruited from the local community and may lack formal education or experience in safe construction practices (Ayii, Multazam and Syam, 2023). As such, rural infrastructure projects, though crucial for improving public health and living standards, can become hotspots for preventable injuries and occupational hazards if they are not managed under robust OHS standards. Personal Protective Equipment (PPE) is one of the most essential elements in any OHS framework. PPE includes safety helmets, gloves, goggles, high-visibility clothing, and other gear to protect workers from site-specific hazards. However, the mere availability of PPE does not guarantee its use or effectiveness (Suprapto *et al.*, 2023).

Training is pivotal in fostering a safety culture on construction sites. Safety training enhances workers' awareness of potential hazards, educates them on correctly using equipment, and reinforces the importance of procedural adherence (Fan *et al.*, 2025). Even the best safety policies and PPE provisions may fail to produce desired outcomes without systematic training. Proper safety education can exacerbate the already precarious conditions under which many labourers operate in rural development projects such as the water supply infrastructure initiative in Samataring Village, Kelara Subdistrict, and Jeneponto Regency. This study is motivated by the urgent need to understand and evaluate how OHS programs are implemented in these high-risk yet under-researched rural contexts. Specifically, it examines the relationship between three key factors: availability of PPE, compliance with PPE usage, participation in safety training and the overall implementation of OHS protocols among construction workers involved in a water supply infrastructure project (Wang *et al.*, 2024). The research employs a cross-sectional quantitative design, targeting 54 construction workers through total sampling (Van Dijk and Moti, 2023). The study aims to contribute practical insights for policymakers, project managers, and occupational health professionals to improve safety outcomes in similar settings by identifying the strengths and weaknesses in OHS implementation (O'Donovan, Giannetti and Pleydell-Pearce, 2024).

In the context of Indonesia's broader development goals, safe and sustainable infrastructure is a national priority. The government's commitment to achieving Sustainable Development Goal 6 (Clean Water and Sanitation) necessitates expanding water access in rural areas (Lin *et al.*, 2025). However, this mission must not come at the

expense of worker safety. Integrating OHS considerations into the planning and execution of infrastructure projects ensures that development is equitable and ethical. The insights from this study can support the integration of OHS standards into rural construction initiatives, providing a template for safer practices across similar environments in Indonesia and other developing nations. In summary, this introduction sets the stage for a comprehensive analysis of OHS implementation in a rural construction project, focusing on the availability and usage of PPE and the provision of safety training. The research fills the knowledge gap on occupational safety in rural infrastructure development. It emphasizes the urgent need for systemic improvements to protect the lives and health of construction workers in underserved regions.

METHODOLOGY

Study Design

This study employed a quantitative research approach using a cross-sectional design to examine the implementation of Occupational Health and Safety (OHS) programs among construction workers engaged in rural water infrastructure development. The cross-sectional method was chosen to analyze relationships between independent variables such as the availability and use of Personal Protective Equipment (PPE) and participation in safety training. The dependent variable is the implementation level of the OHS program.

Study Setting and Period

The research was conducted in Samataring Village, Kelara Subdistrict, Jeneponto Regency, South Sulawesi, Indonesia. This area was selected due to its ongoing water supply infrastructure development project involving multiple construction activities such as water tank construction, pipe excavation, and groundwater drilling. The study took place from July to September 2024.

Population and Sample

The target population included all workers constructing water supply facilities in the designated village. A total population sampling method was applied, resulting in a sample size of 54 construction workers, all of whom were directly involved in the physical implementation of the project. This sampling method ensured that the entire accessible workforce was assessed without additional randomization, enhancing the representativeness and generalizability within the project site context.

Data Collection Methods

Data were collected using two primary techniques: Structured Interviews: A pre-validated questionnaire was administered to all 54 participants. The instrument was designed to gather data on workers' perceptions and experiences related to OHS practices, availability and usage of PPE, and participation in OHS-related training programs. Direct Observation: Field observations were conducted to verify the use of PPE and adherence to OHS protocols during active construction work. Observers used a standardized checklist to ensure objectivity and consistency across different work sites. All participants provided verbal informed consent before data collection, and confidentiality of responses was maintained throughout the study. Variables and Operational Definitions**.** Independent Variables: Availability of PPE: Refers to whether protective gear such as helmets, gloves, boots, and masks were provided and accessible to workers. Use of PPE: Per safety guidelines, assess whether workers consistently wore protective gear. OHS Training: Measures whether workers had previously attended formal training on safety protocols

and occupational hazard prevention. Dependent Variable: Implementation of OHS Program: The extent to which construction workers apply safety measures, comply with safety procedures, and demonstrate awareness of occupational risks during their daily activities.

Data Analysis

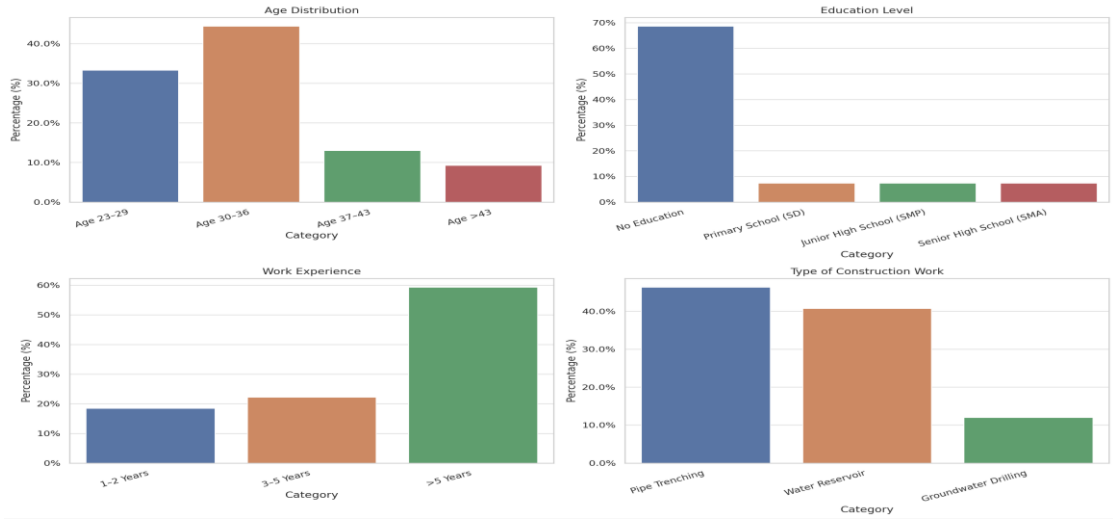
The collected data were processed and analyzed using SPSS software. Descriptive statistics such as frequency distributions and percentages were used to present the demographic and baseline characteristics of the respondents. The Chi-Square (χ^2) test was employed at a significance level of $\alpha = 0.05$ to test the hypotheses regarding associations between variables. This inferential statistical method is suitable for analyzing relationships between categorical variables in cross-sectional studies. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with ethical research standards. Participants were fully informed of the purpose of their involvement, procedures, and voluntary nature. Anonymity and confidentiality were upheld throughout the study. Ethical clearance was obtained from the local ethics committee of the associated academic institution.

RESULT

Chart 1. Visualization in the form of a bar graph of respondent characteristics



Here is a visualization in the form of a bar graph illustrating the characteristics of the study respondents: Age Distribution. The majority of workers are 30–36 years old education Level. Most of them have never received formal education. Work Experience. More than half have more than 5 years of experience. Types of Construction Jobs. Most of them are in the field of digging pipes and building water reservoirs.

Table 1. Bivariate Analysis

The bivariate analysis examined relationships between three independent variables: the availability of PPE, PPE usage, and OHS training participation, as well as the implementation of occupational health and safety (OHS) programs. The Chi-Square test was used to determine statistical significance at $\alpha = 0.05$.

Availability of PPE	Implementing OHS (n)	Not Implementing OHS (n)	Total (n)	p-value
Complete	18 (81.8%)	4 (18.2%)	22	0.003
Incomplete	13 (40.6%)	19 (59.4%)	32	
PPE Usage				
Compliant	25 (75.8%)	8 (24.2%)	33	0.001
Non-compliant	6 (28.6%)	15 (71.4%)	21	
Training Participation				
Attended Training	22 (73.3%)	8 (26.7%)	30	0.008
Did Not Attend	9 (37.5%)	15 (62.5%)	24	

There is a statistically significant relationship between PPE availability and OHS program implementation ($p = 0.003$). Workers with complete access to PPE were significantly more likely to follow safety protocols than those without. A strong, significant correlation exists between PPE use and implementation of OHS programs ($p = 0.001$). Compliant use of PPE was associated with higher adherence to safety measures on-site. Participation in K3 (OHS) training also showed a significant association with OHS implementation ($p = 0.008$). Workers who had undergone training were notably more likely to practice safety protocols than those who had not.

The study's findings underscore the critical role of three main factors in improving safety compliance on construction sites: The availability of PPE ensures that workers have the necessary tools to protect themselves, but this must be coupled with consistent usage. Proper use of PPE significantly enhances workplace safety, reducing the risk of injury or fatality. OHS training contributes to worker awareness and capacity to follow protocols, reinforcing a safety culture. Overall, all three variables demonstrated statistically significant relationships with the implementation of the OHS program, validating the importance of structural and educational support in occupational safety, particularly in rural infrastructure projects.

DISCUSSION

This study aims to analyze the implementation of the Occupational Safety and Health (K3) program for construction workers providing drinking water facilities in Samataring Village, Kelara District, Jeneponto Regency, by focusing on three main variables: the availability of personal protective equipment (PPE), the use of PPE, and construction K3 training. This study's findings show a significant relationship between the three variables and the implementation of the K3 program. These results reinforce previous theories and findings that emphasize the importance of these elements in creating a safe and productive construction work environment.

Availability of Personal Protective Equipment (PPE). The research data showed that of the 22 workers who stated the availability of complete PPE, as many as 81.8% of them implemented the K3 program. Meanwhile, of the 32 workers whose PPE is incomplete, only 40.6% implement the K3 program. The statistical test results showed a significant relationship ($p = 0.003$) between the availability of PPE and the implementation of K3. PPE is one of the important elements in the prevention of work accidents. PPE is a barrier between workers and potential hazards in the work environment, such as impacts, exposure to chemicals, and mechanical risks (Essue *et al.*, 2024). The absence or lack of PPE at the project site contributes significantly to the increased risk of accidents. In addition, the availability of PPE that is not only complete but also ergonomic and comfortable to use also affects the level of use (Peña-Castro,

Montero-Acosta and Saba, 2023). Workers tend to avoid using PPE if they feel uncomfortable or find PPE interfering with work effectiveness. Therefore, the procurement of PPE that meets standards and is practical in its use is very important in supporting the implementation of K3 (Junjia *et al.*, 2024).

Use of Personal Protective Equipment (PPE). PPE was also found to have a significant relationship with the implementation of the K3 program, with a value of p = 0.001. Of the 33 workers who use PPE completely, 75.8% are declared to have implemented the K3 program. In contrast, only 28.6% of workers who do not use PPE implement the program. Compliance with PPE reflects the level of awareness and discipline of workers to the importance of self-protection in the workplace (MacKay *et al.*, 2024). In construction, where the risk of accidents is very high, the use of PPE is the main preventive measure. According to research by Prasetyo (2015), there is a significant relationship between the level of knowledge about occupational hazards and compliance with PPE. However, obstacles to using PPE do not only come from the workers themselves (Hegazy *et al.*, 2024). Organizational factors such as lack of supervision, the absence of a sanction system, or lack of incentives also play a significant role (Man, Wen, and So, 2024). Therefore, project management must build a safety culture by consistently enforcing the rules for using PPE and providing regular training and socialization (Laeke *et al.*, 2024).

K3 Construction Training. The study results showed that workers who had participated in K3 training were more likely to apply to the K3 program than those who had never participated in training. Of the 30 workers who had participated in the training, 73.3% applied K3, while of the 24 workers who had never participated in the training, only 37.5% applied it (p = 0.008). K3 training is one of the means to build workers' knowledge and skills in recognizing, avoiding, and managing work risks. Through training, workers gain theoretical knowledge about potential hazards and best practices for protecting themselves and their colleagues (Bansal *et al.*, 2023). Structured and periodic training also helps strengthen a proactive attitude towards safety (Yiğit and Kazar, 2025). In the context of drinking water infrastructure projects in villages, training is crucial because most of the workforce comes from local communities with low levels of education. This study found that 68.6% of respondents had no formal educational background (De Miguel-Díez and Purfürst, 2025). This reinforces the need for practicum-based training tailored to the worker's comprehension ability, using a visual approach, hands-on demonstration, and local language (Liang *et al.*, 2023).

Sociodemographic Context of Workers. The characteristics of the respondents also provide essential insights related to safety behaviour. Most workers are productive (30–36 years old) and have more than five years of work experience (Thach *et al.*, 2024). Although, in theory, long experience should support compliance with safety procedures, in practice, work experience without adequate training can lead to overconfidence, which reduces caution in the field (Seddighi *et al.*, 2023). The education factor is the most striking aspect. Most workers are not formally educated, which can hinder understanding technical or regulation-based occupational safety procedures. Therefore, risk communication must be delivered, and contextually and difficult technical terms must be avoided (Qi *et al.*, 2023).

Practical Implications

The findings of this study provide important implications for construction project managers, policymakers, and local government project owners. First, it is important to

procure PPE that is complete, accessible, and in accordance with standards. Second, there needs to be a periodic monitoring and evaluation system for the workforce's use of PPE. Third, K3 training must be integrated into the project's initial phase and part of routine activities. The implementation of K3 has an impact not only on safety but also on project efficiency. A safe work environment will reduce the number of accidents, reduce the time of job loss, and improve worker morale, positively impacting productivity and work quality. Research Limitations. This study has limitations in the region's scope and the number of respondents. Because it was only conducted in one village with a limited number of samples (54 people), the results may not be fully generalized to all rural construction projects in Indonesia. In addition, data was collected on a self-reported and simple observational basis, which may be influenced by social bias or subjective interpretation. For further research, it is recommended that longitudinal studies in various areas with experimental designs be conducted, and the contractor or the government should consider organizational factors and safety policies.

CONCLUSION

This study has demonstrated that implementing Occupational Health and Safety (OHS) programs in rural construction projects is significantly influenced by three key factors: the availability of Personal Protective Equipment (PPE), the actual use of PPE, and participation in OHS training. Statistical analysis confirmed strong associations between these variables and adherence to OHS protocols among construction workers involved in a water supply infrastructure project in Samataring Village, Jeneponto. The findings emphasize that providing PPE is insufficient for consistent use, and proper training is equally critical to reducing workplace accidents and enhancing safety performance. In a workforce largely composed of individuals with low formal education, safety practices must be reinforced through accessible training, visual communication, and regular supervision. Implementing a comprehensive and sustainable OHS strategy in rural infrastructure projects protects workers' well-being and contributes to project efficiency, quality, and long-term success. Therefore, stakeholders, including project managers, government agencies, and contractors, must collaborate to ensure that safety systems are systematically applied, continuously monitored, and culturally adapted to the local context.

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Conflict of Interest

There are no potential conflicts of interest relevant to this article.

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