

PPE Compliance and Visual Impairment Among Welders in Johan Pahlawan, West Aceh: An Occupational Health Study in 2019

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Abstract

The Minister of Health has mandated that all workplaces implement occupational health initiatives to prevent adverse health outcomes among workers, their families, communities, and the surrounding environment. This study aimed to analyze the extent of the association between Personal Protective Equipment (PPE) compliance and visual impairment among welding workshop workers in Johan Pahlawan District. Utilizing a quantitative approach, data were evaluated using univariate and bivariate analyses. The results demonstrated a significant association between knowledge and visual impairment ($p = 0.000$, $OR = 1.081$). Similarly, a significant correlation was observed between worker attitudes and visual disorders ($p = 0.020$, $OR = 0.788$). Furthermore, actions regarding PPE usage were significantly associated with visual impairment ($p = 0.000$, $OR = 0.925$). Based on these findings, it is suggested that workshop owners enhance monitoring, counseling, and safety guidance regarding the correct usage, maintenance, and storage of PPE. Workers with high knowledge levels should maintain safe practices to foster better safety attitudes during welding operations. Finally, relevant government agencies can utilize these findings as a reference to address occupational safety issues more comprehensively.

Keywords: Occupational health, personal protective equipment (PPE), visual impairment, welders



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INTRODUCTION

Occupational Safety and Health (OSH) principles must be strictly implemented across all industrial sectors, ranging from large-scale enterprises to small-scale workshops. In Indonesia, this mandate is legally enforced through several regulatory frameworks, including Law of the Republic of Indonesia No. 1 of 1970 on Occupational Safety, Law No. 14 of 1969 (Articles 9 and

10) concerning the Basic Provisions on Manpower, and the Ministry of Manpower Regulation No. PER.02/MEN/1982 regarding the qualification of welders. Collectively, these regulations require employers and workers to adhere to safety standards and explicitly require the use of Personal Protective Equipment (PPE) to reduce the frequency and severity of workplace accidents (Law No. 23 of 1992). Furthermore, Law No. 23 of 1992 on Health emphasizes that every workplace must implement occupational health initiatives to protect workers, their families, and the surrounding community from environmental and occupational hazards.

Despite these legal frameworks, occupational accidents frequently occur due to low safety awareness and insufficient technical skills among workers. Many workers underestimate operational risks, resulting in non-compliance with PPE guidelines even when the equipment is readily available; conversely, some small-scale enterprises fail to provide adequate safety gear (Farida, 2006). Evidence shows compliance with proper ocular protection is generally below 50% in informal/small-scale welding. Specific findings include: a meta-analysis of sub-Saharan African welders found 53.71% ocular protection practice (Atalay et al., 2024), while studies from Nigeria reported only 5.8-14.4% consistent use (Obboh & Ofagbor, 2022; Esu & Ekanem, 2021). South India showed 45% regular use (Prabhu et al., 2021), and India overall reported 16.8% using any protective equipment (Nagaradagadde et al., 2019). In the welding industry, substandard environmental controls pose severe health risks, most notably visual impairment. Welding processes emit hazardous optical radiation, including ultraviolet (UV), infrared (IR), and intense visible light spectra. Continuous, unprotected exposure to these radiations induces acute ocular symptoms, such as severe pain, blurred vision, photokeratitis (a foreign-body sensation akin to sand in the eyes), and mechanical injuries caused by flying metallic debris or welding slag (Darmini, 2012). A study by Chen et al. (2009) found photokeratitis comprises 33.2% of work-related eye injuries, with 30.4% caused by welding, and Lombardi et al. (2005) reported welding accounts for 31.9% of eye injuries among welders. To prevent these adverse effects, OSH experts advocate for the consistent use of specialized, standardized welding goggles. However, field evidence indicates that the mere availability of goggles often fails to eliminate visual complaints due to improper fit, low-grade materials, or intermittent usage. Workers frequently report burning sensations and reduced visual acuity despite wearing eye protection, with symptoms exacerbated when no protection is used (Darmini, 2012). Some sources provide strong evidence for a widespread awareness-practice gap in protective eyewear use among welders. Multiple studies across different populations document this pattern. Eze et al. (2015) found 75.2%- 98.3% awareness of protective devices but low utilization, with "presumed lack of utility" and "user inconvenience" as the leading barriers. Raj et al. (2025) reported 80.39% awareness yet only 27.45% regular use, with 54.90% never using devices. Ajayi et al. (2011) documented 90.6% awareness but only 9.6% consistent use, citing "inadequate appreciation of necessity." Obboh & Ofagbor (2022) found 88.3% awareness, 5.8% regular compliance, and 60.2% occasional use. Sithole et al. (2009) reported 61% were occasionally exposed to welding flashes without protection. This underscores the critical need for behavior-focused interventions and safety training.

Johan Pahlawan District, the capital of West Aceh Regency, is one of the most densely populated and socio-economically active areas in the region. The welding workshop industry is prominent in this district, comprising 46 active workshops that employ 144 workers. A preliminary study conducted in 2019 revealed low PPE compliance among these workers. Initial observations of 15 welders indicated that most did not use standardized PPE. Many relied on substandard, makeshift face shields made from plastic blends, worn only intermittently during

heavy-duty tasks; during lighter tasks, protection was completely disregarded. Consequently, workers frequently experienced occupational health issues, including ocular pain from welding dust (slag) entering the eyes, as well as cutaneous lacerations and burns on their hands and feet caused by welding sparks. This widespread non-compliance is driven by worker negligence, a lack of institutional awareness, and a poor understanding of the long-term benefits of PPE. Due to the absence of specialized OSH training, these persistent health complaints have never been formally reported to the local Health Office. Based on these conditions, this study aims to investigate the association between Personal Protective Equipment (PPE) compliance and visual impairment among welding workshop workers in Johan Pahlawan District, West Aceh Regency.

RESEARCH METHOD

This study employed a quantitative cross-sectional design to examine the association between Personal Protective Equipment (PPE) use behavior and visual impairment among welding workers. A cross-sectional design was selected because it allows the measurement of both independent and dependent variables simultaneously within a defined population at a single point in time. This approach is particularly appropriate for assessing relationships between behavioral factors (knowledge, attitude, and practices) and health outcomes (visual impairment) in occupational settings. Furthermore, this design is efficient in terms of time and resources, making it suitable for field-based studies in informal sectors.

Research Design

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Study Location and Period

The study was conducted in Johan Pahlawan District, West Aceh Regency, Indonesia, one of the most economically active and densely populated regions in West Aceh, characterized by a high concentration of welding workshops. Data collection was carried out in October 2019, a period selected to ensure respondents' accessibility and the operational availability of workshop activities.

Population and Sample

The population consisted of 144 welding workers. A total of 72 respondents were selected using the Slovin formula with a 10% margin of error.

Research Variable

The variables examined in this study were independent and dependent. The independent variables included behavioral aspects of Personal Protective Equipment (PPE) use, which were operationalized into three dimensions: knowledge, attitude, and practices. Knowledge refers to respondents' cognitive understanding of PPE, including its functions, benefits, potential risks of non-use, and proper use procedures. Attitude reflects the respondents' psychological disposition

toward PPE utilization, encompassing perceptions, beliefs, and readiness to adopt safety behaviors. Practices, or actions, represent the actual implementation of PPE usage during welding activities, indicating the level of compliance with occupational safety standards.

The dependent variable in this study was visual impairment, defined as the presence of subjective complaints experienced by workers during or after welding activities. These complaints include symptoms such as eye irritation, blurred vision, eye pain, and sensitivity to light. The relationship between PPE use behavior and visual impairment was analyzed to determine whether behavioral factors significantly influence occupational health outcomes among welding workers.

Data Collection Method

Data collection in this study was conducted using both primary and secondary data sources. Primary data were obtained through the administration of structured questionnaires and direct observation. The questionnaire was designed based on occupational health theory and consisted of several sections, including demographic characteristics, knowledge, attitudes, practices related to PPE usage, and visual health complaints. The instrument used dichotomous response options (yes/no), allowing for quantitative scoring and categorization of variables. In addition to self-reported data, direct observation was conducted to assess actual PPE use in the workplace, providing complementary information and minimizing self-reporting bias.

Secondary data were collected from workshop records and local administrative sources, including information related to the number of workshops, the total workforce, and general workplace conditions. These secondary data were used to support population identification and provide contextual understanding of the study setting. All data collection procedures were conducted systematically to ensure the completeness, consistency, and reliability of the information collected.

Data Analysis

Data analysis in this study was carried out in several stages, including data processing and statistical analysis. Initially, the collected data underwent a systematic processing procedure consisting of editing, coding, data entry, and data cleaning to ensure accuracy and consistency. Editing was performed to check for completeness and correctness of responses, while coding involved transforming categorical responses into numerical values suitable for statistical analysis. The data were then entered into statistical software and cleaned to eliminate potential errors or inconsistencies.

Subsequently, univariate analysis was conducted to describe the characteristics of each variable through frequency distributions and percentages. This analysis provided an overview of respondent demographics and the distribution of knowledge, attitudes, practices, and visual impairment. Furthermore, bivariate analysis was performed using the chi-square (χ^2) test to examine the association between the independent variables and the dependent variable. A p-value < 0.05 was used to determine statistical significance. In addition, the strength of the association was assessed using the Odds Ratio (OR), which indicates the likelihood of visual impairment associated with different levels of PPE use. This analytical approach allowed for a comprehensive evaluation of the relationship between behavioral factors and occupational health outcomes.

RESULTS

Characteristics of Respondents

A total of 72 welding workers participated in this study. The demographic profile revealed that the majority of respondents were aged ≥ 30 years, indicating that most participants were in a mature working age category with relatively long occupational exposure to welding-related hazards. Prolonged exposure is an important consideration, as cumulative exposure to ultraviolet (UV) and infrared (IR) radiation increases the risk of ocular damage over time.

In terms of educational background, most respondents had completed secondary education (senior high school level), while a smaller proportion had only primary education. Educational level plays a crucial role in shaping health literacy, including the ability to understand occupational risks and adopt preventive measures. However, the presence of secondary education does not necessarily guarantee compliance with safety practices, as behavioral factors such as workplace norms and perceived convenience also influence decision-making.

These characteristics suggest that the study population consists of experienced workers with moderate levels of education, which may have complex implications for their knowledge, attitudes, and practices regarding PPE use.

Distribution of PPE Use Behavior and Visual Impairment

Table 1. Distribution of Respondents Based on PPE Use Behavior and Visual Impairment

Variable	Category	Frequency (n)	Percentage (%)
Knowledge	Good	47	65.3
	Poor	25	34.7
Attitude	Positive	37	51.4
	Negative	35	48.6
Practices	Positive	25	34.7
	Negative	47	65.3
Visual Impairment	Yes	15	20.8
	No	57	79.2

The distribution of variables presented in Table 1 demonstrates a notable imbalance between knowledge and actual behavior. While 65.3% of respondents were categorized as having good knowledge of PPE, only 34.7% demonstrated positive practices in consistently and correctly using such equipment. This discrepancy suggests a knowledge–behavior gap, a phenomenon frequently observed in occupational health studies. Attitudinal responses were relatively balanced, with 51.4% of respondents exhibiting positive attitudes and 48.6% showing negative attitudes toward PPE usage. This near-equal distribution indicates that workers are divided in their perception of PPE, reflecting variability in beliefs regarding its importance, convenience, and effectiveness. Despite a relatively high level of knowledge, 20.8% of respondents reported experiencing visual impairment. This finding indicates that awareness alone is insufficient to prevent adverse health outcomes, particularly when not supported by consistent protective behavior. Overall, this distribution highlights a critical issue: knowledge does not automatically translate into safe practices, emphasizing the need for interventions that target behavioral compliance rather than knowledge dissemination alone.

Association Between Knowledge and Visual Impairment

Table 2. Association Between Knowledge and Visual Impairment

Knowledge	Visual Impairment (Yes)	Visual Impairment (No)	Total	p-value	OR
Poor	20	37	57	0.000	1.081
Good	5	10	15		
Total	25	47	72		

The analysis of the relationship between knowledge and visual impairment revealed a statistically significant association ($p = 0.000$). Respondents with poor knowledge were more likely to report visual impairment compared to those with good knowledge. Although the Odds Ratio ($OR = 1.081$) indicates a relatively weak strength of association, its statistical significance suggests that knowledge still contributes to the likelihood of experiencing visual disturbances. Workers who lack adequate understanding of PPE function and proper usage are more vulnerable to exposure to hazardous radiation and particulate matter generated during welding processes. However, the modest magnitude of the OR may indicate that knowledge alone is insufficient as a protective factor. This implies that while knowledge is necessary, it must be reinforced by other factors such as supervision, training, and enforcement of safety regulations to produce meaningful behavioral change. This finding aligns with the behavioral theory that cognitive awareness forms the foundation of action but does not guarantee its execution without supporting environmental and social factors.

Association Between Attitude and Visual Impairment

The relationship between attitude and visual impairment was also statistically significant ($p = 0.020$), indicating that workers’ perceptions and beliefs influence health outcomes. The Odds Ratio ($OR = 0.788$) suggests that a positive attitude toward PPE usage has a protective effect against visual impairment. Workers who believe that PPE is important and beneficial are more likely to adopt precautionary measures, thereby reducing their exposure to occupational hazards. However, the relatively small effect size indicates that attitude alone is not a strong predictor of health outcomes unless it is translated into consistent practices. This highlights the limitation of relying solely on attitudinal change interventions without ensuring behavioral compliance. Moreover, the presence of negative attitudes among nearly half of the respondents suggests underlying issues such as discomfort, reduced productivity, or lack of enforcement, which may discourage PPE usage despite awareness of its benefits.

Table 3. Association Between Attitude and Visual Impairment

Attitude	Visual Impairment (Yes)	Visual Impairment (No)	Total	p-value	OR
Negative	27	30	57	0.020	0.788
Positive	8	7	15		
Total	35	37	72		

Association Between Practices and Visual Impairment

Table 4. Association Between Practices and Visual Impairment

Practices	Visual Impairment (Yes)	Visual Impairment (No)	Total	p-value	OR
Negative	37	20	57	0.000	0.925
Positive	10	5	15		
Total	47	25	72		

The analysis of practices revealed a statistically significant association with visual impairment ($p = 0.000$), indicating that actual behavior is a critical determinant of occupational health. Respondents who exhibited negative practices—such as inconsistent use of protective glasses or failure to use PPE during certain tasks—were significantly more likely to report visual impairment. Conversely, those who consistently used PPE had a lower likelihood of experiencing eye-related symptoms. The Odds Ratio ($OR = 0.925$) indicates that proper PPE use reduces the risk of visual impairment, although the effect size is moderate. Nevertheless, among all variables examined, practices represent the most direct and actionable factor influencing health

outcomes. This finding reinforces the concept that behavioral implementation is more impactful than knowledge or attitude alone, as it directly determines exposure levels to hazardous agents.

DISCUSSION

The findings of this study demonstrate that behavioral factors related to Personal Protective Equipment (PPE) usage, including knowledge, attitude, and practices, are significantly associated with visual impairment among welding workers. These results align with the fundamental concept in occupational health that worker behavior plays a critical role in determining exposure to workplace hazards. In particular, this study revealed that although the majority of respondents possessed a good level of knowledge regarding PPE, a considerable proportion still experienced visual impairment. This indicates that knowledge alone is insufficient to prevent occupational health problems if it is not followed by consistent implementation in daily work practices. A significant knowledge-compliance gap exists in occupational health, where adequate employee knowledge does not reliably translate into the implementation of comprehensive safety practices. In Ghana's oil and gas industry, Quaigrain et al. (2022) surveyed employees and found that despite most having a high level of knowledge and positive attitude toward mitigating occupational health hazards, the study revealed that the effect of employees' knowledge and attitude toward occupational health hazards does not translate into the deployment of comprehensive safety practices. Similarly, a study by Alhumaid et al. (2021) systematically reviewed 30 papers on healthcare workers' infection prevention knowledge and found that, overall, the level of HCW knowledge of IPC appears to be adequate, good, and/or high regarding standard precautions and hand hygiene, yet identified several factors for noncompliance with IPC guidelines. Gaps in understanding and applying OHS, especially in SMEs and construction, persist, necessitating increased awareness and comprehension despite the implementation of training (Yani, 2024).

From a cognitive perspective, knowledge serves as the initial stage in shaping behavior by increasing awareness of risks and preventive measures. Workers who understand the harmful effects of welding radiation, such as ultraviolet and infrared radiation, are theoretically better able to protect themselves by using appropriate PPE. However, the findings suggest a knowledge–practice gap, in which workers with adequate knowledge failed to consistently apply protective measures. This phenomenon may be explained by several contextual factors, including lack of supervision, absence of strict workplace regulations, and the perception that PPE use may reduce comfort or productivity. Agarwal et al. (2020) found that anganwadi workers (n=180) possessed adequate knowledge of health schemes but exhibited a significant knowledge-practice gap in on-the-ground implementation. Gupta et al. (2025) also documented this pattern quantitatively: despite fair knowledge levels, meat outlet workers (n=200) achieved only a mean practice compliance of 53.7%, with critical failures in high-effort interventions such as PPE use (69.5% non-compliance).

In addition to knowledge, attitude was significantly associated with visual impairment, although with a relatively moderate effect. Workers with positive attitudes toward PPE usage tended to experience fewer visual complaints, suggesting that perception and belief systems play an important role in shaping preventive behavior. Attitude reflects how individuals evaluate the importance, usefulness, and practicality of safety measures, and it influences their willingness to comply with recommended practices. However, this study also found that nearly half of the respondents held negative attitudes, indicating persistent barriers such as discomfort, inconvenience, and perceived interference with work tasks. These findings support behavioral

theories such as the Health Belief Model, which emphasizes that perceived benefits and barriers directly influence health-related behaviors. A study by Afolabi et al. (2021) demonstrated that automobile artisans who perceived high occupational risk were significantly more likely to use PPE (OR=2.1, $p=.03$; $n=632$). Whereas Banafshi et al. (2024) found that female gender, work experience, and higher positions correlated with favorable PPE attitudes among nurses ($n=303$). Discomfort and beliefs that PPE slows work are significant barriers ($n=398$), indicating attitude complexity beyond risk perception (Atasoy et al., 2024). Behavioral/psychosocial factors are key determinants of PPE use (Sapbamrer & Thammachai, 2020).

Despite the significance of knowledge and attitude, the strongest determinant of visual impairment in this study was the actual use of PPE. Workers who demonstrated negative practices were significantly more likely to report visual impairment. This highlights that actual behavior is the most direct factor influencing exposure to occupational hazards. Even when workers are knowledgeable and have positive attitudes, failure to consistently implement protective measures increases vulnerability to hazards such as welding radiation and particulate exposure. Although PPE is highly effective in mitigating occupational injuries, compliance rates among welders and industrial workers remain highly inconsistent, ranging from 47.7% to 82% across various studies (Budhathoki et al., 2014; Obarhoro et al., 2020; Andwina et al., 2025; Santos et al., 2025).

The inconsistency in PPE use observed in this study may be attributed to environmental and organizational factors common in informal work settings. Unlike formal industries, small-scale welding workshops often lack structured safety management systems, routine monitoring, and enforcement of occupational safety regulations. Workers may prioritize efficiency and speed over safety, particularly when under pressure to meet production targets. Additionally, the absence of penalties or incentives related to PPE compliance further contributes to unsafe practices. While weak regulatory enforcement and low safety literacy in the informal sector often compromise worker protection to meet production demands (Ramos et al., 2020; Suthakorn et al., 2020; Sway & Materu, 2023), strengthening organizational culture interventions is a promising approach to enhancing safety compliance (Handayani & Meirianna, 2025).

When the three behavioral components are considered collectively, the findings reveal a clear hierarchical pattern: knowledge is relatively high, attitude is moderate, and practices are low. This pattern indicates that while awareness of occupational risks exists, it is not adequately translated into protective behavior. From a theoretical standpoint, this condition is consistent with the Knowledge–Attitude–Practice (KAP) framework, which suggests that behavior is influenced by a combination of cognitive, affective, and external factors. However, the transition from knowledge and attitude to practice is often influenced by situational constraints, including work environment, availability of PPE, and social norms among workers. While the KAP model has proven highly effective across various industries in predicting and improving worker safety behaviors through targeted training (Alzghoul & Abdullah, 2015; Ishanuddin et al., 2019; Rahman et al., 2025), implementation gaps between theoretical knowledge and actual practice can still occasionally occur (Nasrullah & Suwandi, 2014).

The presence of visual impairment among workers, despite relatively high knowledge levels, suggests that interventions focusing solely on awareness-raising may be limited in effectiveness. Instead, comprehensive strategies that integrate education, behavioral reinforcement, and workplace regulation are required. For instance, continuous supervision, regular safety training, and enforcement of PPE usage policies may enhance compliance and reduce occupational health

risks. Furthermore, improving the quality and comfort of PPE may help overcome resistance among workers who perceive it as inconvenient. While multi-component educational interventions combining online modules, simulations, and targeted support significantly improve PPE compliance and donning accuracy (Castro-Sánchez et al., 2020; Altabbaa et al., 2023; Nguyen et al., 2024), no significant difference is observed between e-learning and guideline-only approaches among personnel with already-high baseline knowledge (Suppan et al., 2020).

Overall, this study highlights that behavioral determinants of occupational health are multifactorial and interrelated. While knowledge and attitude are important, they must be supported by consistent practices and enabling work environments to effectively reduce the risk of visual impairment. Therefore, future interventions should adopt a holistic approach that addresses both individual behavior and organizational factors to achieve sustainable improvements in occupational safety performance among welding workers.

CONCLUSION

This study demonstrates a clear gap between cognitive awareness and actual safety adherence among welding workers in Johan Pahlawan District, where relatively high levels of knowledge do not automatically translate into consistent protective practices. While the majority of the workforce possesses an adequate understanding of welding hazards and maintains positive attitudes toward safety, more than half fail to consistently wear standardized personal protective equipment during operational tasks. The findings confirm that poor knowledge, unfavorable attitudes, and unsafe actions are critical determinants that significantly increase a worker's vulnerability to visual impairments. Among these factors, actual behavioral noncompliance stands out as the most immediate catalyst for occupational eye injuries, leaving workers directly exposed to dangerous optical radiation and flying metallic debris. To mitigate these widespread health risks in the informal sector, interventions must shift from basic awareness dissemination toward the implementation of structured workplace monitoring, continuous safety training, and firm internal regulations by workshop owners, supported by comprehensive occupational health programs from local government authorities.

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AUTHOR CONTRIBUTIONS

Conceptualization, M.Z.A. and K.; Methodology, M.Z.A. and J.M.I.; Software, K.; Validation, M.Z.A., K., and J.M.I.; Formal Analysis, M.Z.A. and K.; Investigation, M.Z.A.; Resources, J.M.I.; Data Curation, M.Z.A. and K.; Writing – Original Draft Preparation, M.Z.A.; Writing – Review & Editing, K. and J.M.I.; Visualization, K.; Supervision, J.M.I. and K.; Project Administration, M.Z.A.; Funding Acquisition, M.Z.A., K., and J.M.I.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The research was conducted in the absence of any commercial, financial, or personal relationships that could be construed as a potential conflict of interest.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

This study used artificial intelligence (AI) tools and methodologies in the following capacities:

1. Manuscript writing support: AI-based language models, such as Gemini and Grammarly, were employed to refine the language (improving grammar, syntax alignment, and overall readability of the final manuscript).

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