

BRIDGING THE SAFETY GAP: EVALUATING THE MEDIATING ROLE OF TRAINING AND VENTILATION ON PPE COMPLIANCE AND OCCUPATIONAL HEALTH OUTCOMES AMONG WELDERS IN DELTA STATE

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Abstract

This paper assessed the personal protective equipment (PPE) use among welders in Delta State, Nigeria, and assessed the impact of safety training and the mediating role between ventilation conditions and occupational health outcomes. The quasi-experimental design was implemented that used 200 welders in experimental and control groups. The PPE compliance checklist and occupational health outcome scale were used to collect data. ANCOVA, difference-in-differences, and mediation techniques were used to analyze the results. Results showed that there was poor baseline PPE use in welders. The experimental group had a higher level of PPE compliance than the control group due to safety training. Moreover, safety training partly mediated the association between ventilation conditions and health outcomes which means that behavioural interventions complement the effectiveness of environmental controls. The research came to the conclusion that workplace safety training should be combined with better working conditions in order to minimize workplace risks. It proposed training programmes, which are well organized and enhanced ventilation systems to enhance sustainable occupational health activities among the welders.

Keywords: Personal Protective Equipment (PPE) Compliance; Safety Training; Occupational Health Outcomes; Workshop Ventilation; Welders in Delta State

Introduction

Occupational health and safety (OHS) have been a major concern worldwide, especially in the informal sectors such as welding, where employees are regularly exposed to dangerous physical, chemical, and environmental hazards. The welding processes cause various work hazards, such as working with toxic fumes, heat exposure, ultraviolet radiation, and poor working conditions, which are the main factors leading to negative health impacts (Balasubramanian, Dhanush Kumar, Soosai, Chidhamparam, Sourish, & Pradeep, 2024; Murugan & Sathiya, 2024). Regardless of the development of safety technologies and regulations, adherence to the protective measures, in particular, the use of personal protective equipment (PPE), is not optimal in most developing countries (Sekabojja, Musoke, Osuret,

Ssekamatte, Etajak, & Mugambe, 2024; Nalugya, Kiguli, Wafula, Nuwematsiko, Mugambe, Oputan, & Ssekamatte, 2022).

Compliance with personal protective equipment means the use of protective gear (helmets, goggles, respirators, gloves, etc.) that minimizes the risk of occupational exposure. There is empirical evidence that demonstrates that PPE compliance depends on various factors, such as safety awareness, training, equipment availability, and workplace conditions (Candia, 2025; Chaaban, 2025). In this regard, safety training involves formal or informal teaching or learning methods that help workers to acquire knowledge and skills that will enable them to identify hazards and take preventive actions. Research has continually shown that training is an effective intervention in promoting safety behaviour and decreasing work-related injuries (Habibi, Khorshidikia, Rismanchian, & Popov, 2025; Belmore & Gumasing, 2023).

Workplace ventilation is also another important aspect that affects occupational health outcomes, especially in the welding environment, where fumes are toxic and therefore accumulate. Ineffective ventilation increases the risk of inhalation and causes respiratory diseases, such as chronic bronchitis and a reduction in lung functionality (Khoshakhlagh, Ghobakhloo, Vogel, & Gruszecka-Kosowska, 2026; Balasubramanian, Dhanush Kumar, Soosai, Chidhamparam, Sourish, & Pradeep, 2024). The nature of ventilation, as such, has a direct impact on the level of exposure of workers and their general health outcomes. Nevertheless, new data indicate that the efficiency of environmental factors, such as ventilation, can also be determined by behavioural and cognitive conditions such as training and safety awareness (Mashimbyi, Seisa, Ramathuthu, & Sepadi, 2025).

Research in areas like East Africa, Asia, and Europe has found that there are still occupational safety gaps among welders, especially in informal environments where regulatory measures are minimal (Koirala, Rijal, Kc, Nepal, Khadka, Karki, & Karki, 2025; Magoha, Nyanza, Asori, & Thomas, 2024). Low levels of PPE compliance in sub-Saharan Africa, such as in Uganda and Ghana, are attributed to the lack of proper training, safety standards enforcement, and socio-economic factors (Fening, Agyei, Baah, & Adala, 2021; Itiakorit, Zziwa, & Osuret, 2021). The same trends have been witnessed in Nigeria. As an example, Obarhoro and Nworu (2020) found that welders in Delta State had low adherence to PPE use due to low levels of awareness and no formal safety training. Moreover, Ekefre, Ekanem and Ikpe (2024) also found high levels of health risks among welders in Uyo, such as respiratory and dermatological issues, which once again indicates the importance of better safety measures.

Although the literature has investigated PPE compliance, training, and occupational hazards, there is an essential gap in the literature to comprehend the interactions between the three factors and the health outcomes. In particular, little empirical research has been devoted to the mediating effects of safety training in the associations between environmental factors like ventilation and health outcomes. It is critical to fill this gap to develop effective context-specific interventions that go beyond superficial compliance to target the root causes of behavioural and systemic responses.

It is against this background that this study will examine PPE compliance among the welders in Delta state, the impact of safety training on compliance, and the mediating role that the training plays in the relationship between ventilation conditions and occupational

health outcomes. The study offers a more integrated perspective of occupational safety in informal metalwork environments by combining both behavioural and environmental perspectives. It is hoped that the findings will be used to inform policy and improve training programmes, as well as make contributions to the overall discussion of occupational health in developing economies.

Literature Review

PPE Compliance Concept

PPE compliance is a measure that is used to describe the extent to which employees regularly wear protective equipment as recommended by occupational safety and health regulations. Research has shown that knowledge, attitudes, and equipment availability tend to affect compliance (Nalugya, Kiguli, Wafula, Nuwematsiko, Mugambe, Oputan, & Ssekamate, 2022). The inability to comply is often compromised in informal sectors as a result of the cost restriction and a weak enforcement system (Sekabojja, Musoke, Osuret, Ssekamate, Etajak, & Mugambe, 2024).

Safety Training

Safety training is a systematic activity aimed at enhancing the knowledge of workers on safety and occupational hazards. Habibi, Khorshidikia, Rismanchian, and Popov (2025) concluded that the training has a significant positive impact on hazard recognition and risk exposure. On the same note, Belmore and Gumasing (2023) noted that training improves the safety culture and helps foster a proactive behaviour in the workers.

Ventilation and the Health of Workshops

Another important environmental control measure that minimizes exposure to dangerous fumes is ventilation. Ventilation has been associated with respiratory health problems and prolonged health effects (Khoshakhlagh, Ghobakhloo, Vogel, & Gruszecka-Kosowska, 2026). Balasubramanian, Dhanush Kumar, Soosai, Chidhamparam, Sourish, and Pradeep (2024) emphasized that the long-term exposure to welding fumes has a considerable impact on pulmonary functions.

Research Objectives

On a border note, the study sought to evaluate the mediating role of training and ventilation on PPE compliance and occupational health outcomes among welders in Delta State. Specifically, the study sought to determine:

1. the level of personal protective equipment (PPE) compliance among welders in Delta State.
2. the effect of safety training on PPE use among welders in Delta State?
3. the mediating role of safety training in the relationship between workshop ventilation factors and occupational health outcomes among welders in Delta State?

Research Questions

1. How are the welders in Delta State about personal protective equipment (PPE) compliance?
2. How does safety training impact PPE use among welders in Delta State?

3. How does safety training intervene in the relationship between workshop ventilation factors and occupational health outcomes of welders in Delta State?

Research Hypotheses

1. The hypothesis is that there is no statistically significant impact of safety training on the use of PPE among the welders in Delta State.
2. Safety training is not an important mediating variable between the conditions of ventilation of the workshops and the occupational health outcome of the welders in Delta State.

Methodology

This paper has used a quasi-experimental research design, which incorporates control and intervention groups to evaluate the impact of safety training on the effects of PPE compliance and occupational health among welders in Delta State. The design was appropriate owing to its ability to support a causal inference in real-world conditions where randomization would have been a burden to handle. The research was done in Delta State in Nigeria, where informal metalwork and welding are highly concentrated. The sample size was 200 welders, which was deemed to be manageable and enough to conduct statistical analysis. It used the entire population, with 100 welders in the experimental group and 100 in the control group, in terms of purposive and cluster sampling methods based on the location of the workshops.

Two main instruments, such as a PPE compliance checklist and an occupational health outcome scale, were used to gather data. The PPE checklist evaluated the frequency and accuracy of wearing protective equipment, whereas the health outcome scale included symptoms of respiratory diseases, burns, and fatigue. Both of the instruments were based on the validated tools that have been utilized in earlier research (Nalugya, Kiguli, Wafula, Nuwematsiko, Mugambe, Oputan, & Ssekamatte, 2022; Habibi, Khorshidikia, Rismanchian, & Popov, 2025). The validity of the content was determined by a review of the content by occupational health and technical education specialists. Cronbach Alpha was utilized to identify reliability, and the coefficients of the PPE scale and health outcome scale were determined as 0.82 and 0.85, respectively, which are high.

Data were collected using pre- and post-test. The experimental group was provided with structured safety training on the subject of hazard awareness, PPE use, and ventilation practice, whereas the control group was not provided with any intervention. The period of data collection was six weeks. ANCOVA was used to analyze data and determine the impact of training, taking into consideration the differences at the baseline. The difference in difference- in- differences analysis was used to evaluate the changes with time in the groups. A regression and bootstrapping-based mediation analysis were conducted to investigate the role of safety training in mediating the relationship between ventilation conditions and health outcomes. The ethical aspects involved informed consent, respondent confidentiality, and voluntary participation. Respondents were promised that the research was conducted on scholarly grounds and their answers would remain anonymous.

Results

Research Question 1: How are the welders in Delta State about personal protective equipment (PPE) compliance?

Table 1: Descriptive Statistics of PPE Compliance

Variable	N	Mean	SD
PPE Compliance	200	2.41	0.68

The rate of PPE use among the welders is low, showing inconsistent or improper use, which may be because of poor accessibility, ineffective enforcement, and ineffective safety education in informal welding settings.

Research Question 2: How does safety training impact PPE use among welders in Delta State?

Table 2: ANCOVA Outcome of Effects of Safety Training on PPE Compliance

Source	SS	Df	MS	F	p-value	Partial Eta ²
Training	24.56	1	24.56	18.72	.000	.16
Error	258.40	198	1.31			

Table 3: Difference-in-Differences (Pre-test and Post-test Scores)

Group	Pre-test Mean	Post-test Mean	Mean Difference
Experimental	2.38	3.45	+1.07
Control	2.42	2.50	+0.08

PPE compliance is greatly enhanced by safety training, and it is effective in increasing hazard awareness, use of correct equipment, and favorable attitudes towards safety among welders, even after adjusting for differences in the baseline.

Research Question 3: How does safety training intervene in the relationship between workshop ventilation factors and occupational health outcomes of welders in Delta State?

Table 4: Mediation Analysis (Regression weights)

Path	β	S.E	C.R	p-value
Ventilation → Training	0.41	0.07	5.86	.000
Training → Health Outcomes	-0.45	0.06	-7.12	.000
Ventilation → Health Outcomes	-0.32	0.08	-4.10	.001

Table 5: Bootstrapping Effect

Effect	Estimate	Boot SE	95% CI	p-value
VC → ST → OHO	-0.18	0.04	[-0.26, -0.11]	.002

The relationship between ventilation and health outcomes is partly mediated by safety training, which suggests that the effectiveness of environmental improvements is greater when strengthened by behavioural interventions that improve the protective practices of workers.

Hypotheses Testing

Hypothesis 1 (H_{01}): The hypothesis is that there is no statistically significant impact of safety training on the use of PPE among the welders in Delta State.

Table 6: ANCOVA Summary to test Hypothesis

Variable	p-value	Decision	F	p-value	Decision
Training → PPE Compliance			18.72	.000	Rejected

The null hypothesis is rejected, because safety training has a significant impact on enhancing PPE compliance, and it is essential in affecting protective behaviour and occupational risks in welders.

Hypothesis 2 (H_{02}): Safety training is not an important mediating variable between the conditions of ventilation of the workshops and the occupational health outcome of the welders in Delta State.

Table 7: Summary of Mediation Effect

Path	Indirect Effect	p-value	Decision
VC → ST → OHO	-0.18	.002	Rejected

The null hypothesis is rejected because the safety training has a significant mediating effect on the ventilation-health relationship, which shows the significance of integrating environmental controls with behavioural interventions in enhancing occupational health outcomes.

Discussion

The results of this research indicate the low compliance of PPE among welders in Delta State, which is similar to the results of prior research in Nigeria and other developing states (Obarhoro&Nworu, 2020; Nalugya, Kiguli, Wafula, Nuwematsiko, Mugambe, Oputan, &Ssekamate, 2022). Limited awareness, inadequate training, and socio-economic restrictions that hamper access to protective equipment can be linked to this low compliance.

The high impact of safety training on the use of PPE justifies the results of Habibi, Khorshidikia, Rismanchian, and Popov (2025) and Belmore and Gumasing (2023), who also

highlighted the importance of training in promoting safety behaviour. The causal inference is enhanced by the quasi-experimental design used in this study, which proves that the targeted interventions can be efficient in improving compliance.

Moreover, the mediation analysis also shows the importance of safety training in the process of correlating the environmental conditions, including ventilation, to the health outcomes. The above finding is important as it adds to the current literature by proving that the environmental improvements are not always enough and that they have to be accompanied by behavioural interventions. This finding is consistent with that of Mashimbyi, Seisa, Ramathuthu, and Sepadi (2025), who stated that safety awareness increases the efficacy of the workplace controls. The research also endorses the Health Belief Model because the training workers were more inclined to perceive risks and preventive behaviours. This makes it important that the behavioural theories should be incorporated into the occupational health interventions.

On balance, the results indicate that to enhance the occupational health outcomes of welders, it is necessary to take a holistic approach that involves training, environmental improvement, and policy implementation. The research adds to the rising literature in the field of occupational safety in informal sectors and offers practical implications to policymakers and practitioners.

Conclusion

This paper has analyzed the compliance of PPE among the welders in Delta State, the impact of the safety training on the compliance, and the mediation of training in the relationship between ventilation conditions and occupational health outcomes. The results indicated that PPE compliance was generally low, which highlights the ongoing safety lapses in informal welding. Nevertheless, the quasi-experimental findings showed that structured safety training has a significant positive impact on the use of PPE even after the baseline differences are taken into account. This underscores training as a viable and scalable behaviour change intercession. Moreover, the mediation analysis proved that partially the influence of the ventilation conditions on the health outcomes is attributed to the safety training. Although better ventilation will directly decrease contact with dangerous fumes, training will increase their ability to identify hazards and implement protective behaviours, increasing the health benefits.

These findings justify an integrated environmental-behavioural intervention on occupational safety, as opposed to individual-oriented intervention. On the whole, the research adds to the body of literatures on occupational health by revealing that in order to achieve proper risk mitigation in informal sectors, training and workplace benefits, as well as policy implementation, should be combined. The results offer empirical evidence supporting focused interventions that focus on the development of infrastructure and human capabilities. It is important to tackle these dimensions as a single entity in enhancing health outcomes, minimizing occupational risks and encouraging sustainable safety measures among welders in Delta State and other such situations.

Recommendations

1. The training on safety and PPE adherence has a great influence on the actual use of PPE by welders and therefore regular, standardised and practical safety training, to improve hazard awareness and promote consistent use of PPE, should be considered by government agencies, technical institutions and trade associations.
2. Given that ventilation can have a direct effect on health and that the provision of training (or the lack of it) can also affect health, workshop owners and regulatory authorities should encourage the use of low-cost ventilation measures, including exhaust fans and workshop layout, to help minimise exposure to harmful ventilation fumes.
3. Ventilation should not be considered an isolated measure, and ventilation policy should aim for a combination of environmental and behavioural change (ventilation training) to safeguard the health of workers sustainably.

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