



## Knowledge and Safety Practices Related to Exposure to Physical and Chemical Hazards among Welders in Sokoto, Nigeria

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### Authors' contributions

This work was carried out in collaboration between all authors. Authors KJA, MAM and MTOI gave the study concept and design, and drafted the manuscript. Authors AS, TGM and FGM gave the study concept and design, and performed data collection, analysis and interpretation. All authors read and approved the final manuscript.

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### ABSTRACT

**Introduction:** The workplace is an important part of man's environment, and there is no occupation that is free of hazards. Due to the upsurge in construction activities (many of which involve welding) sequel to the increasing urbanization and industrialization across the world, exposure to occupational hazards has become an important public health problem globally. This study was conducted to assess the knowledge and safety practices related to exposure to physical and chemical hazards among welders in Sokoto, Nigeria.

**Methods:** A cross-sectional descriptive study was conducted among 280 welders selected by systematic sampling technique. Data were collected with a set of standardized, semi-structured, self-administered questionnaire, and analyzed using the IBM SPSS Version 20 statistical computer software package.

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**Results:** The mean age of the respondents was 30.98±9.42 years, and all of them were males. Majority, 197 (70.4%) of the 280 respondents had good knowledge of the physical and chemical hazards of welding. Most of the respondents (66.4% to 95.7%) were aware of the various workplace accidents and injuries of welding. Almost all the respondents (99.3%) had good knowledge of prevention of welders' workplace hazards, accidents and injuries. Although, most of the respondents reported observing the various preventive measures against welders' workplace hazards, accidents and injuries, consistent use of personal protective equipment (PPE) was poor, and this was majorly attributed to non-availability. Almost all the respondents (99.3%) have experienced workplace accidents and injuries, with the most common injuries sustained being cut injuries to the fingers and other parts of the body (86.1%), burns from fire or explosions (86.1%), and eye injuries due to sparks (78.6%).

**Conclusion:** The low utilization of PPE and the correspondingly high prevalence of accidents and injuries despite good knowledge of welding hazards and their prevention among welders in Sokoto, Nigeria, underscore the need for government, employers and other stakeholders to promote ownership and consistent use of PPE, in addition to monitoring welders and their employers for compliance with workplace health and safety standards.

*Keywords: Knowledge; safety practices; physical and chemical hazards; welders.*

## 1. INTRODUCTION

The workplace is an important part of man's environment, and there is no occupation that is free of hazards [1]. A worker may be exposed to five different types of hazards depending upon his occupation. These include physical, chemical, biological, mechanical and psychosocial hazards [1]. Welding is an important tool for maintenance and construction in industry but, it is also a source of artificial ultraviolet radiation (UVR) [2]. Welding emits high levels of UVR, metal fumes and gases and exposure to these adverse effects could potentially cause injury to workers [2,3]. Exposure to UVR has been considered to be associated with many ocular conditions such as cataract which is the major cause of blindness in most parts of the world including South Africa [4,5].

Even when not welding, welders may be inadvertently exposed to arcs of nearby welders [6]. It has been estimated that about half of welder's flash injuries occur in co-workers who are usually in the immediate vicinity of where welding takes place but not being involved in welding [7].

The welding work processes is also associated with the risk of other physical injuries such as cuts, burns and hearing impairment resulting from loud noises [8]. There is also a risk of psychosocial hazards such as stress at work and exhaustion in addition to ergonomic hazards that mainly involve musculoskeletal injuries such as muscle sprains, muscle pain, dislocation and fractures [9,10].

Due to the upsurge in construction activities (many of which involve welding) sequel to the expanding urbanization and industrialization across the world, exposure to occupational hazards has become an important public health problem globally [11]. According to the World Health Organization (WHO) and International Labor Organization (ILO) estimate for the year 2000, about 2 million people die each year as a result of occupational accidents and work-related illness or injuries [12]. Another 268 million non-fatal workplace accidents result in an average of three lost days per casualty, as well as 160 million new cases of work-related illness each year [12]. Occupational hazards also account for 2.3% of disability adjusted life years (DALYs) lost among middle-income countries [13]. In Nigeria the real incidence of occupational accidents, fatalities as well as deformities is not well recorded. A Nigeria based study showed that between 1987 and 1991, there were 2,012 reported cases of industrial injuries among workers in Nigerian factories with an average of 402 accidents per year [14].

Exposure to occupational hazards with the resultant injuries, diseases and death has profound effects both on work productivity and on the socioeconomic well-being of the workers and their families. These hazards are very common in the informal sector (such as welding) which is inadequately supervised and lacks occupational health services [15]. In addition, because of inadequate financing and difficulties in obtaining credit facilities, small scale industries (such as welding) use poor outdated machinery and equipment, thus limiting their productivity and increasing exposure to hazards [16].

Reports from previous studies in Nigeria show high prevalence of work-related accidents or illnesses among welders. In a study by Okuga et al, 92% of welders reported injuries or illnesses related to work, with cuts and burns cumulatively accounting for 73% of all injuries. Other injuries reported include backache and chest pain (14%), eye injuries (6%) and hearing problems (6%) [17]. In another study among welders in Kaduna, Nigeria, 85.3% of the subjects had experienced one or more work related accidents or occupational hazards, and the most prevalent injury among them was cut/injuries to the hands and fingers (38.0%) [18]. In view of the rising prevalence of occupational diseases and injuries globally, there is a need for a greater focus on preventive activities. Reports from studies conducted in other places show that workers are unaware of the occupational hazards to which they are exposed [19,20]. Prevention of these hazards cannot be promoted among workers if they lack knowledge of their respective workplace hazards. This study was conducted to assess the knowledge and safety practices related to exposure to physical and chemical hazards among welders in Sokoto, Nigeria. The findings from this study would be useful to policymakers, employers of labor and other stakeholders in the construction industry in developing appropriate strategies for promoting optimal workplace safety among this "at risk" group of workers.

## 2. MATERIALS AND METHODS

A cross-sectional descriptive study was conducted among welders in Sokoto metropolis, Nigeria, between July and September 2013. Welders who have been in practice for at least 6 months and consented to participate in the study were considered eligible for this study.

The sample size was estimated at 279 using the Fisher's formula for estimating minimum sample size for descriptive studies [21], a 77.9% prevalence of awareness of at least one workplace hazard among welders from a previous study [18], a precision level of 5% and an anticipated participant's response rate of 95%. The eligible study participants were selected by systematic sampling technique in the respective clusters of welding workshops in Sokoto metropolis.

A standardized, semi-structured, interviewer-administered questionnaire was developed and used to obtain information on participants' socio-demographic characteristics, knowledge of

welders' workplace hazards and their prevention, participants' safety practices and prevalence of accidents and injuries among them. It was reviewed by researchers in the Department of Community Health, Usmanu Danfodiyo University, Sokoto, Nigeria, to ascertain content validity. The questionnaire was pretested on 20 welders in a cluster of welding workshops that was not used for the study. Some questions were rephrased for clarity based on the observations made during the pretesting. Three resident doctors assisted in questionnaire administration after being trained on the conduct of survey research, the objectives of the study, and administration of the survey instrument.

Institutional ethical clearance was obtained from the Ethical Committee of Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria. Permission to conduct the study was obtained from the Executives of the Welders' Union and the owners of the selected shops. Informed written consent was also obtained from the participants before questionnaire administration.

Data were analyzed using the IBM SPSS Version 20 statistical computer software package. Respondents' knowledge of physical and chemical hazards of welding (likewise prevention of welders' workplace hazards, accidents and injuries) was scored and graded on an 8-point scale. One point was awarded for a correct response, while a wrong response or a non-response received no points. This gives a minimum score of '0' and a maximum score of '8' points. Those that scored  $\geq 5$  of 8 points were considered as having 'good' knowledge, while those that scored  $< 5$  of 8 points were graded as having 'poor' knowledge. Frequency distribution tables were constructed; and cross tabulations were done to examine the relationship between categorical variables. The chi-square test was used to compare differences between proportions. All levels of significance were set at  $p < 0.05$ .

## 3. RESULTS

### 3.1 Socio-demographic Characteristics of Respondents

Two hundred and eighty of the 287 questionnaires administered were adequately completed and used for analysis giving a response rate of 97.6 percent. The ages of the 280 respondents ranged from 18 to 56 years (mean =  $30.8 \pm 9.5$ ), and majority of respondents 191 (68.2%) were aged 20 – 39 years. All the

respondents were males; and majority of them were married 158 (56.4%) and practice Islam as religion 238 (85.0%). Majority of respondents had formal education 216 (77.1%), and have worked for less than 10 years 146 (52.1%) as shown in Table 1.

**Table 1. Socio-demographic characteristics of respondents**

Variables	Frequency (%) n = 280
<b>Age group (in years)</b>	
Below 20	31 (11.1)
20-29	111 (39.6)
30-39	80 (28.6)
40-49	47 (16.9)
50 and above	11 (3.9)
<b>Marital status</b>	
Single	122 (43.6)
Married	158 (56.4)
<b>Religion</b>	
Islam	238 (85.0)
Christianity	42 (15.0)
<b>Education</b>	
Informal (none and quranic school only)	64 (22.9)
Formal (primary, secondary and tertiary)	216 (77.1)
<b>Type of welding</b>	
Arc welding	230 (82.1)
Gas welding	50 (17.9)
<b>Length of practice (in years)</b>	
< 10 years	146 (52.1)
≥ 10 years	134 (47.9)

### 3.2 Respondents' Knowledge of the Physical and Chemical Hazards of Welding

Almost all, 278 (99.3%) of the 280 respondents were aware that their occupation exposes them to at least a type of physical or chemical hazard. Majority of respondents, 197 (70.4%) also had good knowledge of the physical and chemical hazards of welding. The physical hazards most commonly known to the respondents were musculoskeletal problems (87.5%) and harsh weather conditions (72.9%); also, the chemical hazards most commonly known to them were irritant gases (76.8%), metal fumes (72.1%), and metal dust (72.1%). Majority of respondents also knew the other physical and chemical hazards of welding as shown in Table 2.

The proportion of respondents with good knowledge of the physical and chemical hazards

of welding was significantly higher ( $p < 0.05$ ) among the married (77.8%) compared to the singles (60.7%), Christians (95.2%) compared to Muslims (66.0%), those involved in gas welding (82.0%) compared to those involved in arc welding (67.8%), and those that have worked  $\geq 10$  years (77.6%) compared to those that have worked for  $< 10$  years (63.7%) as shown in Table 3.

### 3.3 Awareness of the Workplace Accidents and Injuries of Welders by Respondents

Most of the respondents were aware of the accidents and injuries welders are exposed to at the workplace. The workplace accidents and injuries of welders most commonly known to the respondents were cut injuries to the fingers or other parts of the body 268 (95.7%), eye injuries due to sparks 243 (86.8%) and burns from fire or explosions 240 (85.7%). Most of the respondents also knew the other workplace accidents and injuries of welders as shown in Fig. 1.

### 3.4 Respondents' Knowledge of Prevention of Welders' Workplace Hazards, Accidents and Injuries

Almost all, 278 (99.3%) of the 280 respondents had good knowledge of prevention of welders' workplace hazards, accidents and injuries. The preventive measures most commonly known to the respondents were use of personal protective equipment (99.3%), provision of water and soap for washing hand and face (98.9%), and keeping the work site clean and orderly (98.2%). Most of the respondents also knew the other preventive measures as shown in Table 4. There was no association ( $p > 0.05$ ) between good knowledge of prevention of welders' workplace hazards, accidents and injuries and any of the respondents' socio-demographic variables.

### 3.5 Respondents' Practices on Prevention of Welders' Workplace Hazards, Accidents and Injuries

Most of the respondents reported observing the various preventive measures for welders' workplace hazards, accidents and injuries. The preventive measures most commonly observed by the respondents were keeping the work site clean and orderly 276 (98.6%), use of personal protective equipment 273 (97.5%) and welding in the open space 269 (96.1%). Majority of respondents also observed the other preventive

measures except provision of fire extinguisher at the workplace which was observed by less than half 127 (45.4%) of the 280 respondents, and only about two-thirds 33 (66.0%) of the gas welders reported keeping their gas cylinders away from sources of heat (Fig. 2).

Whereas majority, 186 (66.4%) of the 280 respondents consistently wear eye goggles, only a few consistently wear hand gloves (24.3%) and boots (15.4%) while welding. Consistent use of

the other personal protective equipment was very poor, only a few respondents consistently wear apron (5.0%), helmet (4.3%), face mask (3.6%) and ear plugs (3.2%). Although about half, 141 (50.4%) of the 280 respondents occasionally wear hand gloves while welding, most of them have never used personal protective equipment like helmet (83.2%), ear plugs (83.9%), apron (59.6%) and boots (52.5%) while welding (Table 5).

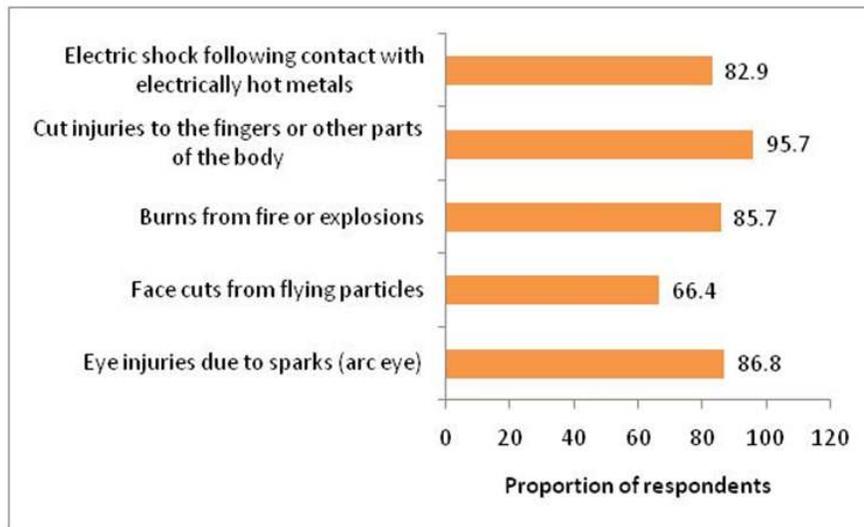


Fig. 1. Awareness of the workplace accidents and injuries of welders by respondents

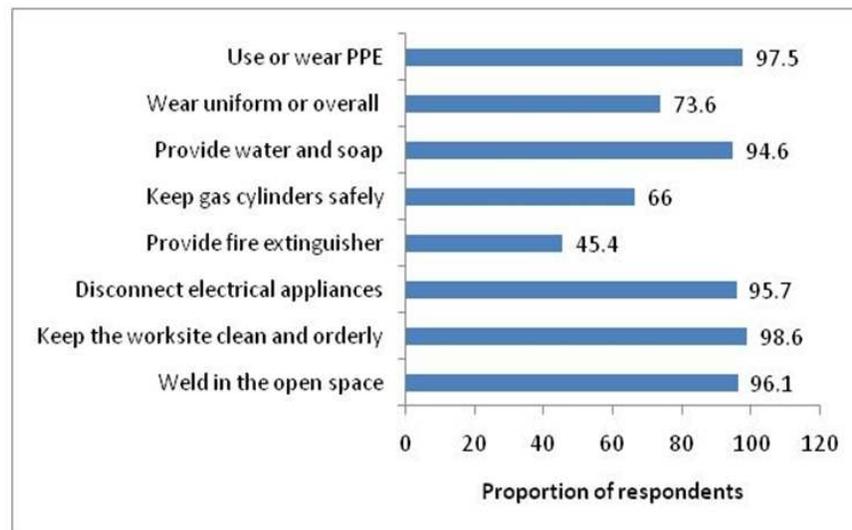


Fig. 2. Respondents' practices on prevention of workplace hazards, accidents and injuries

**Table 2. Respondents' knowledge of the physical and chemical hazards of welding**

Hazards of welding	Correct response frequency (%) n = 280
<b>Physical hazards</b>	
High noise level from welding equipment and power sources (generators)	179 (63.9)
Harsh weather conditions such as excessive heat and cold	204 (72.9)
Non-ionizing radiations	196 (70.0)
Musculoskeletal problems such as back pain, joint pain, sprains etc.	245 (87.5)
<b>Chemical hazards</b>	
Metal fumes	202 (72.1)
Mineral dust	202 (72.1)
Irritant gases	215 (76.8)
Solvents	178 (63.6)
<b>Knowledge grade</b>	
Good	197 (70.4)
Poor	83 (29.6)

**Table 3. Distribution of knowledge of the physical and chemical hazards of welding by respondents' socio-demographic variables**

Variables	Knowledge of hazards (n = 280)		Test of Significance
	Good frequency (%)	Poor frequency (%)	
<b>Age group (in years)</b>			
< 40	154 (69.4)	68 (30.6)	$\chi^2 = 0.501$ , p = 0.479
≥ 40	43 (74.1)	15 (25.9)	
<b>Marital status</b>			
Single	74 (60.7)	48 (39.3)	$\chi^2 = 9.757$ , p = 0.002
Married	123 (77.8)	35 (22.2)	
<b>Religion</b>			
Islam	157 (66.0)	81 (34.0)	$\chi^2 = 14.667$ , p < 0.001
Christianity	40 (95.2)	2 (4.8)	
<b>Education</b>			
Informal (none and quranic school only)	43 (67.2)	21 (32.8)	$\chi^2 = 0.400$ , p = 0.527
Formal (primary, secondary and tertiary)	152 (71.3)	62 (28.7)	
<b>Type of welding</b>			
Arc welding	156 (67.8)	74 (32.2)	$\chi^2 = 3.956$ , p = 0.047
Gas welding	41 (82.0)	9 (18.0)	
<b>Length of practice (in years)</b>			
< 10	93 (63.7)	53 (36.3)	$\chi^2 = 6.485$ , p = 0.011
≥ 10	104 (77.6)	30 (22.4)	

Whereas majority of PPE non-users cited non-availability as the main reason for not using PPE such as helmet (82.6%), ear plugs (88.5%), face mask (65.5%), apron (64.8%) and boots (57%), experience of discomfort was cited as the main reason for not using hand gloves (89.8%) while welding (Fig. 3).

### 3.6 Prevalence of Workplace Accidents and Injuries among Respondents

Almost all, 278 (99.3%) of the 280 respondents have experienced accidents and injuries at the workplace. The accidents and injuries most commonly experienced by the respondents were

cut injuries to the fingers and other parts of the body (86.1%), burns from fire or explosions (86.1%), eye injuries due to sparks (78.6%), electric shock (77.1%), and back pain, sprains and joint pains (76.1%). Close to half of

respondents (43.9%) have had face cuts from flying particles; whereas a few have experienced hearing impairment (21.8%), fracture (6.1%) and amputation of fingers (2.1%) as shown in Table 6.

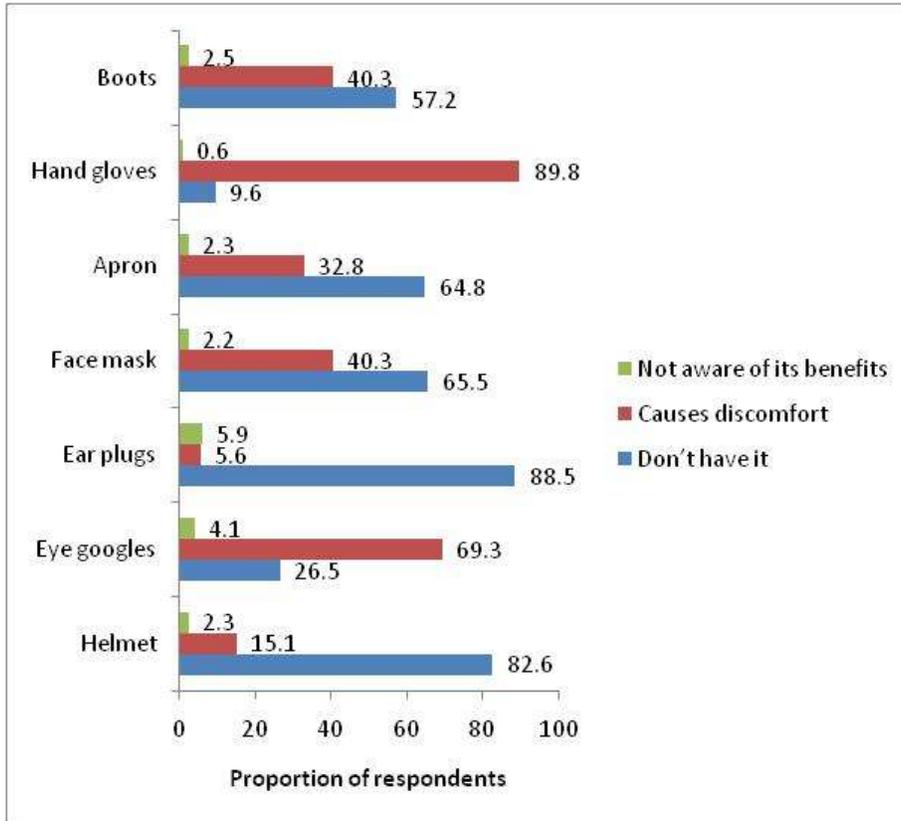


Fig. 3. Reason for not using personal protective equipment

Table 4. Respondents' knowledge of prevention of welders' workplace hazards, accidents and injuries

Preventive measures	Correct response Frequency (%) n = 280
Weld in the open space instead of an enclosed space	267 (95.4)
Keep the worksite clean and orderly	275 (98.2)
Disconnect electrodes and all electrical appliances after work	267 (95.4)
Provide fire extinguisher in the workplace	257 (91.8)
Keep gas cylinders away from sources of heat	83 (29.6)
Provide water and soap for washing hand and face	277 (98.9)
Wear uniform or overall while welding	268 (95.7)
Use or wear personal protective equipment	278 (99.3)
<b>Knowledge grade</b>	<b>Frequency (%)</b>
Good	278 (99.3)
Poor	2 (0.7)

**Table 5. Use of personal protective equipment by respondents while welding**

Personal protective equipment (PPE)	Frequency of use			
	Always number (%)	Very often number (%)	Occasionally number (%)	Never number (%)
Helmet	12 (4.3)	7 (2.5)	28 (10.0)	233 (83.2)
Eye goggles	186 (66.4)	44 (15.7)	34 (12.1)	16 (5.7)
Ear plugs	9 (3.2)	2 (0.7)	34 (12.1)	235 (83.9)
Face mask	10 (3.6)	36 (12.9)	81 (28.9)	153 (54.6)
Apron	14 (5.0)	11 (3.9)	88 (31.4)	167 (59.6)
Hand gloves	68 (24.3)	44 (15.7)	141 (50.4)	27 (9.6)
Boots	43 (15.4)	1 (0.4)	89 (31.8)	147 (52.5)

**Table 6. Prevalence of workplace accidents and injuries among respondents**

Variables	Frequency (%) n = 280
<b>Ever experienced workplace accidents and injuries</b>	
Yes	278 (99.3)
No	2 (0.7)
<b>*Accidents and injuries ever experienced</b>	
Eye injuries due to sparks (arc eye)	220 (78.6)
Face cuts from flying particles	123 (43.9)
Burns from fire or explosions	214 (76.4)
Cut injuries to the fingers and other parts of the body	241 (86.1)
Electric shock	216 (77.1)
Bone pain, sprains and joint pain	213 (76.1)
Hearing impairment	61 (21.8)
Fracture	17 (6.1)
Amputation	6 (2.1)

*\*Multiple responses allowed*

#### 4. DISCUSSION

The welders in this study were relatively younger (mean age = 30.98 ± 9.42) than the welders in a study in Ile-Ife, south - western Nigeria that reported a mean age of 39 ± 18 years [22]. All the respondents were males, whereas this is in consonance with the finding in a study among welders in Kaduna, northern Nigeria [18], in which all the respondents were males, it is in contrast to the finding in a study among welders in Ile-Ife, south - western Nigeria [22], that reported a small female population (0.7%). This could be related to differences in socio-cultural factors in the study areas, in addition to the general perception of welding as a male occupation.

Whereas, the awareness of at least one type of workplace hazards by almost all the respondents in this study (99.3%) is in agreement with the

90.7% awareness of workplace hazards obtained among welders in Nepal [23], it is substantially higher than the 86.5% awareness obtained among welders in Addis Ababa, Ethiopia [24], and the 77.9% awareness obtained among welders in Kaduna, Nigeria [18]. This study also showed good knowledge of the physical and chemical hazards of welding by majority of respondents (70.4%). An intriguing finding in this study is the fact that whereas there was association between good knowledge of workplace hazards and working experience ( $p < 0.05$ ), it was not associated with educational attainment. This is in contrast to the findings in the other studies as they found direct association between awareness of workplace hazards and both educational attainment and work experience [18,23,24]. The uniformly significant association between good knowledge of workplace hazards and work experience obtained in this study and the other studies could be due to the fact that the

longer the duration of practice the more the risk of exposure to workplace hazards and their adverse effects.

Of serious concern are the very low utilization of personal protective equipment (ranged from 3.3 to 66.4%) and the high prevalence of accidents and injuries (99.3%) despite high levels of awareness of workplace accidents and injuries (ranged from 66.4 to 95.1%) and good knowledge of prevention of workplace hazards, accidents and injuries (99.3%) among the respondents in this study. Whereas awareness of both workplace hazards and preventive measures were correspondingly high among the respondents in this study, the respondents in a study among welders in South India were more aware of hazards (83.3%), than safety measures (64.1%) [25]. Similar to the finding in this study, a study among welders in Port Harcourt also reported a high level of awareness of the risk of sustaining an eye injury, and only 15.3% of those that sustained eye injuries were using protective eye wears at the time of the injuries [26]. In contrast to the low utilization of PPE among the respondents in this study, the welders in the study by Kumar et al. [25] reported a substantially higher utilization of PPE (95.7%), even though awareness of welders' workplace hazards and safety measure was relatively lower among them compared to the respondents in this study. Even though non-utilization of personal protective equipment among the respondents in this study was majorly attributed to non-availability, the fact that discomfort was cited as the main reason for not using hand gloves is disturbing, and it came as no surprise that cut injuries to the fingers were the most common injuries sustained by them (95.7%). The finding of cut/injuries to the fingers as the most common injuries in studies conducted among welders in the sub-Saharan African countries [17,18] is worrisome enough, as it shows that a substantial proportion of workplace injuries among welders across the continent and their adverse effects on the productivity and the quality of life of those affected are largely preventable.

Similar to the finding in this study, reports from other studies also show wide gaps between knowledge of workplace hazards and use of personal protective equipment among welders. In a study among welders in Ile-Ife, despite a high level of awareness of workplace hazards and protective devices (90.6%), less than half of them (45.9%) possessed protective eye devices; and of these, only 9.6% made use of the devices

always (and the inconsistent use was mainly attributed to discomfort and poor visibility) [22]. In the study among welders in Kaduna [18], whereas majority of respondents (77.9%) were aware of workplace hazards, only 34.2% of them used one or more types of protective devices.

The finding of non-availability of PPE being the major reason for not using it among the respondents in this study is in consonance with the findings in studies conducted in other places. A study among welders in Jinji, Uganda [17], attributed the workplace injuries sustained by the participants majorly to lack or insufficient use of personal protective equipment (64.0%). Other reasons given were carelessness (16%), and fatigue caused by overworking and lack of modern equipment (16%). In another study among arc welders by Megbele et al. [27], majority of the eye injuries (72%) occurred during welding and grinding operations, and only 60% of them were wearing eye protection when the eye injuries occurred. These findings show that even though knowledge of workplace hazards, accidents and injuries, and their prevention are generally important in facilitating compliance with workplace health and safety practices; specifically, prevention of workplace accidents and injuries is contingent on availability and use of PPE.

## 5. CONCLUSION

The low utilization of PPE and the correspondingly high prevalence of accidents and injuries despite good knowledge of welding hazards and their prevention among welders in Sokoto, Nigeria, underscore the need for government, employers and other stakeholders to promote ownership and consistent use of PPE, in addition to monitoring welders and their employers for compliance with workplace health and safety standards.

## CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

## ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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