



Knowledge about Physical Hazards and Use of Personal Protective Equipment Based on Demographic Characteristics and among Small Scale Welders in Nairobi City, Kenya

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Authors' contributions

All authors contributed to the design, data collection and analysis. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: The sprawling of small and medium-sized enterprises (SMEs) in the developing world provides several challenges to ensuring health and safety practices among workers in the urban poor.

Purpose: The main objective of the study will be to determine the knowledge of physical hazards and the use of PPEs based demographic characteristics among welders in Embakasi constituency, Nairobi County.

Methods: This was a cross-sectional descriptive study conducted among 214 welders from 72 workshops in the Embakasi region, namely in Kariobangi South Light Industries, Kayole, and Umoja. Data collection procedure entailed observation, focus group discussions, and interviews with welders in Embakasi, Nairobi. Data were analysed using SPSS version 22 and both descriptive statistics and inferential statistics were conducted to explain the association between the study variables.

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Results: The study indicated that 90.2% of welders knew the activities at the workplace that pose health hazards. Welders' knowledge of physical hazards at their workplace was significantly associated with experience (Fishers Exact Test =45.025, $p = .05$), number of hours worked per day (Fishers Exact Test = 9.322, $p = .05$), and PPE use ($\chi^2 = 3.884$, $df = 1$, $p = .05$).

Conclusion: Factors such as age, earning a level, hours per day worked, level of education, type of training, and knowledge of physical hazards or PPE use are significantly associated with self-reported injuries among welders.

Keywords: Hazards; safety; SMEs; welders.

1. INTRODUCTION

Worldwide, more than 50 percent of workers are engaged in the informal sector marked by non-existent regulatory enforcement for occupational health and safety standards. As a result, according to the World Health Organization (WHO), occupational exposure to hazardous risks affects about 2.9 billion workers globally, leading to varied consequences. In the developing countries, about 12.2 million people of working age die from non-communicable diseases and injuries annually. A significant portion of non-communicable diseases is mainly accounted for by occupational injuries. These include 37 percent of all musculoskeletal injuries, 16 percent of hearing loss, 9 percent of lung cancer, and 8 percent of injuries [1].

Welding is one of the occupations associated with these occupational health hazards in both developed and developing countries. The injuries vary. A case study in France offers new insights into the epidemiology of mesothelioma and confirms risks for occupational activities described in earlier studies that workers such as welders in the metal industry have elevated the risk of the disease [2]. In a quasi-experimental study in the Rio Grande do Sul (RS), Brazil, there was a significantly increased symptom for the cardiovascular, respiratory and cutaneous systems associated with welding activities [3]. However, there was a negative correlation between the welders' ages and the detection of health disorders.

In India, majority of welders (59%) complained of eye symptoms, followed by skin irritation (26%), which saw the researchers recommending health and safety training for this group [4]. In another study, abrasion was the most common type of injury, followed by lacerations and foreign particles in the eye. Flash burns and contusion were the least common types of injuries identified by this study. This study pointed out that welding activities are mainly carried by younger working

group aged between 20 and 40 [5]. In Sri Lanka welders were at an increased risk of developing chronic bronchitis with non-impairment of lung function [6].

Regionally, there are few studies in Africa on occupational injuries among welders. In a study conducted among welders in Kaduna, Nigeria, cuts to the hands and fingers, followed by musculoskeletal pain (back/waist pain) were the most prevalent injuries, eye injuries only comprised 17% of the injuries [7]. This study indicated a high level of knowledge of occupational hazards; however, the use of protective measures against the hazards was sub-optimal. These findings have been supported by a South African study where burns were higher among welders (46%) due to lack of use of protective gloves [8].

In Kenya, very few studies have been conducted on occupational health hazards among Jua Kali workers, much less welders. The available studies investigate the occupational hazards among artisans (Jua Kali workers), with welders as a subset of this group. In a study on health effects of lead exposure among Jua Kali workers in Mombasa, radiator repairers were the most affected (83.3%), followed by painters (16.67%), and metal fabricators (11.76%) in terms of blood lead level (BLL) [9]. The incident of ocular injury was more common among metal workers (33.3%) compared to other Jua Kali activities [10]. Regardless of a large number of studies that have been done both nationally and internationally to shed light on the link between welding activities and occupational injuries, there is still a wide gap in the exploration of the mediating roles of knowledge of physical hazards and the adoption of safety measures among welders.

The regulations on safety and welfare of all workers in Kenya are stipulated in the Occupational Safety and Health Act (2007) [11]. Despite the legislation put in place by the

Government of Kenya to safeguard the safety and health of workers, the number of occupational accidents is still high, with more than 50% accidents unreported [12]. In 2012, there were 6,019 industrial accidents with 257 deaths. This figure is a slight decrease from the 6,023 accidents recorded in the 2010-2011 financial year [13]. Even though the largest proportion of fatalities is in the transport sector, most accidents and injuries are in the manufacturing and agricultural sectors. In 2010-2011, the industrial sector entailing manufacturing of machinery and fabricated metal products where welders largely belong recorded 177 accidents [14].

As per the results of the 2009 Kenya national census, the majority of the working population is employed by the informal sector. Compared with 1.2 million workers in the formal sector, the informal sector and small-scale enterprises employ approximately 12 million workers. The statistics indicate that more than 75% of the working population in Kenya is employed in the informal sector. With the current rate of unemployment in Kenya, these figures are expected to rise [15]. Despite Light Industries and other “jua kali” areas in Embakasi comprising a significant region where metalwork has been conducted for years, many workers and employers are still oblivious of the associated occupational hazards; research also shows that about 41% are unwilling to use personal protective equipment [16]. In Kariobangi Light Industries, the previous study indicated that about 34.48% of workshops rarely implement fire safety [17]. In May 2011, eight workers lost their lives at Picasso workshop in Kariobangi Light Industries [18]. Many have workers have been reported to have suffered serious injuries, and some have even lost their lives from the complication associated with nature of work such as welding. The spill-over effect of such of work-related injuries on families have also been reported, particularly huge healthcare bills, lasting effects such as maiming, and loss of breadwinners which plunge dependents into poverty. Workers in the informal sector are, however, adversely affected due to their dismal enrolment in the National Hospital Insurance Fund (NHIF), which is 19% as indicated by the Deloitte survey [19].

2. METHODS

This was a cross-sectional descriptive study conducted in Embakasi, Nairobi County of

Kenya. The independent variables included demographic characteristics (age, gender, level of education, and income), work-related factors (job duration, training prior to induction, and experience), and the presence of physical hazards such as bright light, extreme heat, noise, projectiles, and sharp objects, etc. The dependent variable was the self-reported health effects of exposure to physical hazards such as respiratory symptoms, eye symptoms, burns, cuts, impaired hearing, etc.

There were 72 metal workshops in the study area. A sample size of 228 respondents was drawn from the 72 workshops according to the ratio of workshops in the area in order to acquire a homogenous sample [20]. Purposive sampling was undertaken to identify the Jua Kali regions: Kariobangi South (Kariobangi Light Industries), Kayole, and Umoja due to the high population density of welders in these regions. The researcher took the names of every metalworker in each workshop register. Simple Random Sampling (SRS) using computer-generated random numbers was used to select the names of welders who constituted a sample size of 228 respondents from the 72 workshops. To construct a simple random sample, the researcher then drew out a certain percentage of names at random. SRS ensured that all subjects (welders) from the Jua Kali regions have equal chances of being enrolled for the study [20].

Data was collected through focus group discussions, observation, key informant interviews, and the administration of questionnaires to the respondents. During the data collection process, the researcher conducted quality checks of all the interviews and discussions and assisted in getting clearance from the workshop owners and health facilities. SPSS version 22 was used to analyze data from the research. This entailed an analysis of both descriptive (median, mean, percentage, and standard deviation) and inferential statistics (Chi-square test and Fisher exact test). Inferential statistics was used to verify the association between occupational injuries and selected variables. Thematic analysis was used to identify, analyze, and report themes or patterns within qualitative data. The researcher was able to categorize various types of injuries, types of physical hazards, and safety measures from the welders' perspective through thematic analysis.

Authorization to conduct the research was sought and obtained from the Kenyatta University Graduate School. Ethical clearance was obtained from Kenyatta University Ethics, and Review Committee and the approval to conduct the research was obtained from the National Commission of Science, Technology and Innovation (NACOSTI). Further permission was also sought from various Jua Kali associations such as Kariobangi South Jua Kali Association as well as the County Commissioner Office. The study participants were informed of the study and given a consent form to sign, which also explained the purpose of the study. Once they had understood the purpose of the study and agreed to take part, the participants were asked to sign the consent.

3. RESULTS

Out of the 228 sampled welders, 214(93.9%) responded to the questionnaires. More details are shown in Table 1.

3.1 Work-related Factors

The majority of the respondents were arc welders (58.9%, 126). Other work-related factors are captured in Table 2.

3.2 Types of Physical Hazards

Several categories of physical hazards were described by the respondents as shown in Fig. 1 and Table 3.

Most welders complained that they were exposed to bright light (94.4%) and electric shock (93.5%) at their places of work. Causes of electric shocks ranged from illegal connections, faulty wires, to working on wet grounds without proper earth wire or safety boots. Welders also complained about intense glares, particularly when working in confined places under poor lighting as reported below verbatim:

"Electric shock is the most common type of welding hazard." - **A welder in Kariobangi FGD.**

"In most cases, workers fall when tripped by wires on the ground or workpieces that are unattended to hence increase the risk of electric shock and other injuries." - **Workshop owner in Umoja.**

"Exposed or uninsulated wires are the main cause of electric shock." - **Leader, Kayole Jua Kali Association.**

Table 1. Demographic characteristics of study respondents (n=214)

Parameter	Variables	Number (%)	Mean	Standard deviation
Age groups	< 25	51 (23.8)	19.4	17.9
	26-35	63(29.4)		
	36-45	55(25.7)		
	>=46	45(21.0)		
Marital Status	Single	47(22.0)	29065.9	13324
	Married	145(67.8)		
	Widowed	9(4.2)		
	Divorced/separated	13(6.1)		
Income level	<=20,000	19(9)	29065.9	13324
	20,001-40,000	154(72)		
	40,001-60,000	32(15)		
	>=60,001	9(4)		
Highest level of education	Non-formal schooling	9(4.2)	29065.9	13324
	Primary	58(27.1)		
	Secondary	126(59.3)		
	Vocational training	14(6.5)		
	College/University	6(2.8)		
Residence	Kariobangi South	87(40.7)	29065.9	13324
	Kayole	75(35.1)		
	Umoja	52(24.3)		

Table 2. Work-related factors (n=214)

Type of welding	Frequency	Percentage
Gas	14	6.5
Arc	126	58.9
Both	74	34.6
Total	214	100
Numbers of years worked as a welder	Frequency	Percentage
< 1 year	50	23.4
1 - 5 years	124	57.9
6 – 10 years	18	8.4
> 11 year	22	10.3
Total	214	100
Hours per day	Frequency	Percentage
< 5 hours	36	16.8
5 – 8 hours	166	77.6
> 8 hours	12	5.6
Total	214	100
Type of training	Frequency	Percentage
Self-taught	31	14.5
Apprenticeship	163	76.2
Vocational training	11	5.1
College/University	9	4.2
Total	214	100

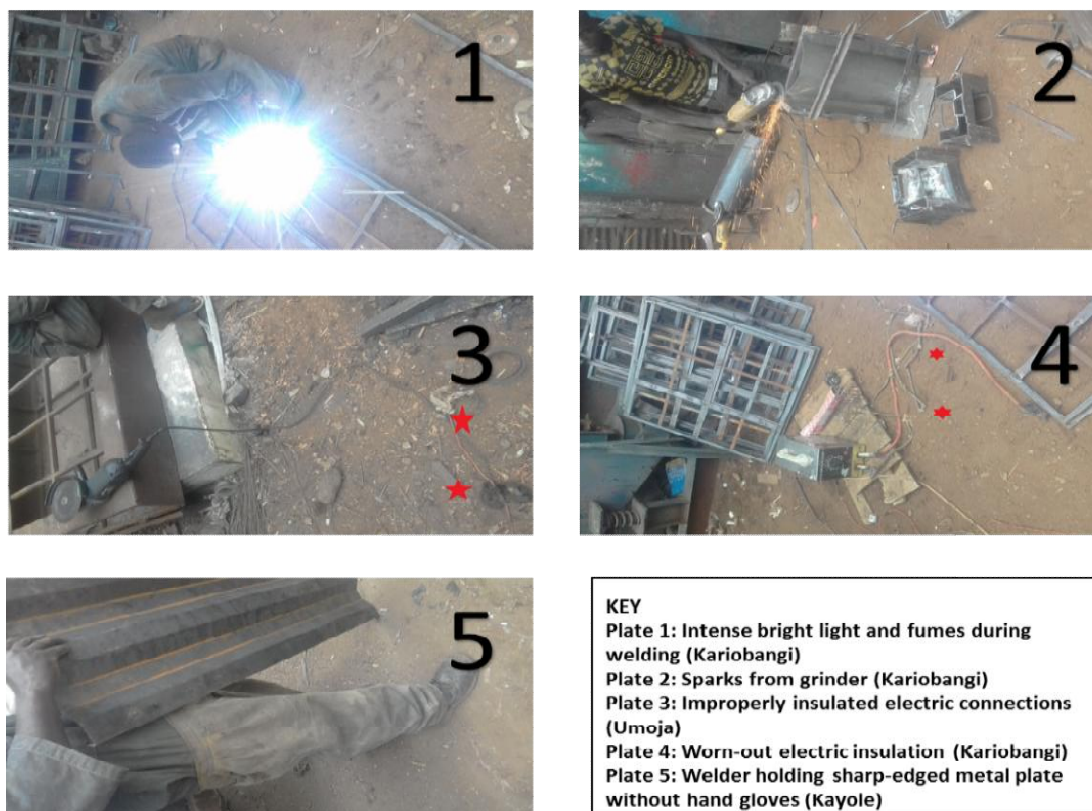


Fig. 1. Observed hazards among welders in various areas

Table 3. Types of physical hazards reported (n = 214)

Type of physical hazards reported	Number (%)
Heat	132 (61.7)
Bright light	202 (94.4)
Electric shock	200 (93.5)
Sharp edge metals	167 (78)
Welding fumes	101(47.2)
Projectiles	188(87.9)
Noise	192(89.7)
Vibration	93(43.5)

3.3 Knowledge of Physical Hazards

Almost all of those interviewed, 209 (97.7%), knew about fire hazards. The majority, 211 (98.6%) of the respondents knew about electrical hazards. Most of the study subjects, 186 (86.9%) knew about hazard prevention and those who could correctly identify at least two physical hazards, 193(90.2%), were considered knowledgeable about physical hazards while 21(9.8%) who could mention less than two were considered less knowledgeable. Responses were sought from different groups of welders according to their experience in the trade: less than 1 year, 1 to 5 years, 6 to 10 years, and over 11 years. There was a statistically significant association between numbers of years as a welder and the knowledge of hazardous activities at the workplace (Fishers' Exact Test = 45.025, *p = .05). A significant association was also noted between numbers of hours worked per day by a welder and the knowledge of hazardous activities at the workplace (Fishers' Exact Test = 9.322, *p = .05). Those who work for longer hours (5 to 8 hours or more than 8 hours) were more likely to know about hazards compared to those who are not.

Key informant interviews at the study area also affirmed that most welders worked for long, hence increasing their exposure to the physical hazards. In Kariobangi South, most welders work for longer hours to meet deadlines and in some cases to handle other duties at their workplaces such as automobile repair and painting:

"My welders work for longer hours especially when I have a strict deadline to meet."
Workshop owner, Kariobangi.

Since most welders did not receive formal training in welding, they tend to learn the risks to

exposures to hazards and PPE use while working at the workshop.

"Most of my workers have not been trained to work as welders...only through an apprenticeship in metal cutting did they learn how to weld and protect themselves from hazards" **Chairperson – Umoja Jua Kali Association.**

3.4 Personal Protective Measures Adopted

Out of the 214, majority, 200 (93.5%) knew about safety goggles and insulated gloves, 187 (87.2%). Other PPEs such as safety boots, face shield, gas mask, and welding shield were unpopular, accounting for less than 10% use by welders. Those who correctly identified at least two PPEs, 161(75.2%), were considered knowledgeable about PPEs while 53(24.8%) who could mention less than two were considered less knowledgeable, with the results indicating that 71.5% percent used mentioned PPE regularly. Those who reported using PPE were 131 (61.2%), with 77(58.8%) using the equipment regularly. Safety goggles (93.5%) were the most commonly used PPE followed by insulated gloves (87.2%). Usage of other PPE was dismally low, at less than 2%. Most welders reported that PPEs were quite expensive and were not provided at work. Thus, the high cost of PPE (22%) was the most common reason for not using PPE.

At least half of the respondents (52.8%) carried out maintenance on their work equipment after one year, while others carried out maintenance after every six months (24.3%) or when necessary (22.9%). It was also reported that 92.5% of the respondents did not read equipment safety manual, had no first aid equipment (89.7%) or fire extinguisher at the workplace (92.1%). Among the 90 respondents observed, only 40% reported owning the PPE, 23% were observed using the PPE, and 33.3% used appropriate PPE for their work. Appropriate handling of PPE such as wiping or cleaning after use and storing in the tool safety box was noted in 54 of the 90 observed respondents while 51 of the respondents (57%) had their PPE in good working condition, that is, free from dust as well as wears and tears. Details of the area of work linked to welders' workplace safety standard such as a well-lit workshop, well-arranged working area, electrode safety, presence of fire extinguisher, among others were also observed. The researcher also observed most welders

(>90%) working near public pathways, and lifting heavy loads without support (>90%). Most workshops were outdoor and well lit (96%) and had electrodes disconnected from the holder (74%). About 44% of the workshops were well-arranged, while few workshops had secured gas cylinder (13%), use screen to confine welding processes (18%), had a suitable fire extinguisher (15%), and had safety placards on the wall (13%).

3.5 Knowledge of Physical Hazards, Demographic Characteristics and Use of PPEs

Chi-square results show a statistically significant difference in PPE use and knowledge of hazards at workplace ($\chi^2 = 3.884^*$, $df = 1$, $p = .05$). Those who are knowledgeable of hazards are more likely to use PPE compared to those who are not. There was no significant association among knowledge of physical hazards, social demographic characteristics, and PPE use. Fisher's exact test revealed no significant association between PPE use and the number of hours worked per day by welders, welder's experience, type of training, as well as the type of welding activities ($p > .05$).

4. DISCUSSION

This study sought to test the hypothesis that there was no association between knowledge about physical hazards and the use of personal protective equipment based on demographic characteristics and among small scale welders in Nairobi city, Kenya. The overall response rate for this study was 93.9% (214/228). This implies that the findings of the study are highly generalizable to the population of welder where it was conducted. Majority of respondents were aged between 26 and 35 (29.4%). This could be due to apprenticeship setting where the youth join the profession earlier and settle on other managerial positions or duties in their late 40's. This finding is supported by a similar study conducted in 2006 in Nigeria among 758 welders [21]. The present study also indicates that 90.2% knew about the activities at the workplace that pose health hazards, with fire hazards reported by almost all welders (97.7%). About 75.2% of the respondents knew that PPE could be used to protect workers from hazards. Similar previous studies cited several hazards associated with injury or harm at welding workplace including bright light, heat, fire or explosion, electricity,

sharp edges/metals, welding fumes and gases, flying sparks/particles, noise, falling objects, vibrations, uncomfortable work postures and the use of PPE in hazards prevention [22-24].

Even though various types of welding are common in industrial settings, arc welding (SMAW, also known as manual metal arc welding, MMAW or stick welding) accounts for 58.9% of the type of welding followed by those who practice both arc welding and gas metal arc welding (GMAW or metal inert gas welding) (34.6%). This finding is comparable to other studies among welders in the developing countries such as Nigeria, India, and Nepal [22-24]. Since MMAW is the most common method of welding, it has been linked to increased risks of exposure to hazards such as fumes, gases, and UV radiation [21]. In the current study, an appreciable number of welders also reported practising gas welding thus increasing their risk of exposure to other physical risks such as heat and fumes. In the present study, welders in the "jua kali" setting were observed working for more than 8 hours in an unfavorable environment, including direct sunlight, and dusty open-air workshops. Bright light, excessive heat, projectiles, and sharps (reported by over 90% of respondents) were the most common hazards.

Most welders were observed manually lifting heavy tools and metals, thus straining themselves. In addition, most workshops were either located near public pathways or roads thus risking the lives of the workers and road users. Several studies confirm that small scale enterprises are characterized by poor working environments. Compared to larger industries, workers in SMEs tend to work long hours in poor conditions thus exposing themselves to more risks [25-26]. In the research conducted by Rongo et al. [27]. In Tanzania, it was found that welders in SMEs are more likely to be exposed to several health hazards compared to other workers including carpenters, painters, and metalworkers. In another study conducted by Joshi and Dahal in Nepal, it was reported that welding not only presents risks to welders but also the residents and passers-by near welding workshops. These findings indicate that physical hazards in welding workshops are not only risky to welders but also present a significant public health hazard [28].

Similarly, it was indicated that the effects of welders' experience, hours per day worked and the level of knowledge of physical hazards was

significant ($p = .05$). This finding is supported by a similar study conducted by Tadesse, Bezabih, Destaw and Assefa in Addis Ababa which indicated that the likelihood of hazard knowledge among welders who had extended experience was almost six times higher compared to those who had worked for less than five years [29]. This could be explained by the possibility of longer working hours, prolonged occupation, and increased age-associated with familiarity with the work environment and improved skills or good knowledge of welding techniques.

The present study indicates that about 75.2% of them knew that PPE could be used to protect workers from hazards. The findings indicate that PPE used were safety goggles (93.5%) and insulated gloves (87.2%). Despite the increased level of knowledge, most welders were still at risk of eye injuries, burns, and cuts since safety goggles and insulated gloves only offer minimal protection. The use of other important safety gears such as welding shield, gas mask, safety boots, and face shield was still predominantly low ($< 5\%$ respondents), thus explaining the injuries sustained from gases, from fumes, glare, cuts, and burns. This is consistent with a survey in Nepal which indicated that safety goggles and gloves record predominant usage compared to other PPEs such as face shield, overalls, as well as hearing and respiratory PPE among welders [26].

Majority of welders had attained either primary level (27%) or secondary level (59.3%) of education, with very few attaining tertiary or vocational training. This finding points towards the need for education for workers regarding workplace hazards and PPE use. Chauhan, Anand, Kishore, Danielsen, and Ingle assert that PPE use is dependent on the knowledge of occupational hazards among workers. Similar to the present study, workers with increased knowledge can transform the available information into an advanced stage that enhances the need for protection [4]. The finding is also consistent with the study conducted by Tadesse, Bezabih, Destaw and Assefa which indicate that appropriate knowledge regarding workplace hazards is crucial to developing safety education programs, training on the appropriate design of tools and machines to use to have enhanced efficiency of both man and machine and PPE use [29].

In this study and others, knowledge of occupational hazards was found to be significantly associated with the adoption of

safety measures such as PPE use [5]. It is known that workers who are more knowledgeable about physical hazards are more likely to comply with safety regulations such as PPE use. Thus, the incorporation of safety programs is vital in building a safety culture. Unlike other studies [24,29]. This study did not find any association between educational level, age, and marital status with the knowledge of workplace hazards. This is unlike the study by Okuga, Mayega, and Bazeyo which explains that younger welders (<20 years) tend to disregard personal safety [30].

Reported respiratory symptoms included wheezing, shortness of breath, and cough, eye symptoms and metal fume fever including sweet metallic taste in the mouth, body chills and fever, general body weakness, and flu-like symptoms. The most prevalent self-reported health conditions in the present study were eye-related symptoms, cuts, and burns to the hands and feet ($>95\%$) associated with most hazards such as bright light, sharp objects, and extreme heat ($p<0.001$). Similar study report eye-related morbidity as well as cuts and burns as the most prevalent injuries among welders [22]. This study reported significant associations between injuries and factors such as age, earning a level, hours per day worked, level of education, type of training, and knowledge of physical hazards or PPE use as supported by previous studies [23, 29,30]. The present study reported fewer respiratory symptoms such as wheezing and shortness of breath. This could be explained by the lack of appropriate instrumentation in assessing respiratory conditions. Similarly, since most welders work in open-air spaces exposure to dust or smoke were limited compared to other physical hazards such as excessive heat and sharp objects. Fewer reported cases could also be explained by the exodus of workers with severe respiratory complaints from the welding occupation. These consequences highlight the need for appropriate use of protective devices while working to prevent related symptoms [4].

5. CONCLUSION

Physical hazards associated with welding activities in Embakasi include electric shocks, sharp objects, bright light, excess heat, etc. Hours worked, work experience and PPE use are among the factors significantly associated with knowledge of physical hazards at welders' workshops. Most welders reported having sustained cuts, burns, and electric shocks during

their daily welding routine. The study also concluded that most welders use PPE, particularly safety goggles and insulated gloves to safeguard themselves against hazards. Use of other PPEs such as face shield, overalls, respirators, gas masks, helmets, etc. is low hence the increase of eye and respiratory symptoms as well as cuts and burns among welders.

The responses were probably affected by recall bias when welders reported morbidities from past exposures. This study was also limited by the transitory nature of SME workers and finding welders who are not involved in competing tasks such as painting and panel beating, among others. Only the welders, working at workshop or garages were included in the study. This study did not address any confounding factors.

Like any other study requiring self-reporting, the present study was limited by social desirability bias. Most welders only reported what was socially accepted by their colleagues or employers rather than their day-to-day encounters at work. Thus, future study should emphasize on measures for reducing bias related to self-reporting and the limitations of cross-sectional study design. Future studies should thus examine the causal relationships between welding hazards and outcomes of exposure.

To reduce occupational health-related problems associated with physical hazards among the welders, several measures should be implemented:

- a) Employers should ensure welders are trained and educated on physical hazards, including types of physical hazards and protection approaches needed to deal with the hazards. Health and safety agencies such as the National Environment Management Authority (NEMA) and the Directorate of Occupational Safety and Health Services (DOSHS) should regularly inspect welding workshops for hazards and welders advised on how to reduce incidents of overexposure to physical hazards by working under recommended daily hours to reduce overexposure.
- b) The Ministry of Health and other line ministries in collaboration with the media and advocacy groups should run a work safety intervention programs on the effects of workplace hazards via social media,

radio and television advertisements, posters, and leaflets.

- c) There is also a need for a vibrant welder's union that should make adequate and proper representation to the Nairobi County Council and the Directorate of Occupational Safety and Health Services (DOSHS) on issues affecting welders.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by the personal efforts of the authors.

CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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