

**Occupational Hazards and Use of Personal Protective Equipment among
Small Scale Welders in Lusaka, Zambia**

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University of Bergen, Norway
May 2015**

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This thesis is submitted in partial fulfilment of the requirements for the degree of
Master of Philosophy in International Health at the University of Bergen.

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Abstract

Introduction

Welding is associated with various inherent occupational hazards which may result in severe consequences on health of workers performing this task. Very little information exists regarding health hazards and how they are controlled among welders in developing countries. For instance, there is limited information on use of personal protective equipment or work related health problems within this occupational group. Little information is published concerning welders in Zambia, although the number of welders is increasing, especially in small scale enterprises. Thus, the study aimed to gather information about occupational hazards and use of personal protective equipment (PPE) among small scale welders in Lusaka, Zambia. Acute health effects experienced by the welders were also explored as well as the welders' awareness regarding occupational hazards and use of PPE.

Methods

This was a cross sectional study of 430 small scale welders conducted in Lusaka, Zambia. A pretested structured interview guide and checklist was used to collect data on demographic characteristics, work experience and occupational hazards, awareness of PPE and hazards, use of PPE and acute health effects experienced. Descriptive statistics were used in the analyses of data, Chi square and ANOVA tests were used for comparing study variables and a generalised linear model with a log link function was used to derive relative risks.

Results

It was found that welders were exposed to welding hazards such as intense bright light, heat, noise, fumes and gases. Other hazards arose from poor housekeeping, unsafe work structures and tools such as grinders. Although the majority (98%) of welders were aware of at least one type of welding hazard or PPE, about 2% were not aware of any hazards or any personal protective measures. None of the welders used all the recommended PPE at any time during

their work. A high prevalence of self-reported eye (88%) nasal (78%), metal fume fever (68%) and respiratory (64%) related symptoms was found in addition to burns (87%) and cuts (79%) on hands/arms. Education was associated with awareness regarding hazards and PPE as well as use of PPE.

Conclusion

Welders in this study worked under poor and dangerous conditions that exposed them to several safety and health hazards. Although most welders were aware of occupational hazards and related PPE for their work, this awareness did not translate into use of PPE. Their use of protective measures did not offer the level of protection required considering that a high prevalence of acute health effects was found among the welders in the study. This calls for concern and need for more preventive measures within this occupational group to avoid injuries and diseases.

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Acronyms and Abbreviations

ANOVA	Analysis of Variance
CI	Confidence Interval
ERB	Ethics Review Board
GLM	Generalised Linear Model
HAVs	Hand Arm Vibration syndrome
HSD	Honestly Significant Difference
ILO	International Labour Organisation
IR	Infra-Radiation
LCC	Lusaka City Council
MCTI	Ministry of Commerce, Trade and Industry
MMAW	Manual Metal Arc Welding
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
RR	Relative Risk
SD	Standard Deviation
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for Social Scientists
TDI	Texas Department of Insurance
UV	Ultra-Violet Light
WHO	World Health Organisation
WISE	Work Improvement in Small Enterprises
ZRA	Zambia Revenue Authority

Definitions As Applied In the Study

Acute Health effects: Health effects experienced as a result of exposure to hazards during or immediately after work, or within a period of two weeks after exposure to hazards at work.

Occupational Hazard: Any activity, process or materials related to welding with the potential to cause harm or adverse health effects on people performing this task.

Personal Protective Equipment: Devices (i.e. goggles, respirators/face masks, welding helmets/shield, safety boots, fire resistant aprons, work suit/coverall and insulated gloves) used to prevent or reduce exposure of the welders to workplace hazards.

Risk: The probability of harm or an adverse health effect occurring to a person exposed to a hazard.

Small Scale Enterprise: A business entity whose total number of workers is less than 10. These may or may not be registered with the company registrar of Zambia.

Welder: Any person who performs welding processes including apprentices.

Welding: The process of joining metal pieces by means of molten metal that is produced at the joint by heat, pressure or both heat and pressure.

Acknowledgements

Firstly, I would like to thank my supervisors, Bente E. Moen and Magne Bråtveit for their unwavering support and expertise guidance throughout my study and the entire research process. I will forever remain indebted to them for the research skills and scientific knowledge I have acquired through their mentorship. Their dedication and professionalism is truly worth emulating.

In full gratitude, I acknowledge the participation of the welders in making this research possible. I extend my thanks to the faculty members at the Centre for International Health (CIH) and members of the occupational health research group for the lectures and discussion on various aspects of occupational and international health. Many thanks also to Gunhild, Borgny and Linda for their assistance with administrative logistics. I highly appreciate the financial support of the Norwegian Government through the Quota Scheme for financing my studies.

My heartfelt gratitude extends to the faculty members in the Department of Public Health at the University of Zambia for their support and encouragement. To my classmates, the Fantoft Christian Fellowship members, the Zambian community and friends in Bergen, thank you for your encouragements, prayers, and most of all, for the precious time we spent together that made my experience in Bergen memorable. It was always comforting to know that I had a family away from home. To Chisala D. Meki, thank you for sharing this wonderful experience with me, for being there when I needed a friend. I also thank my loving family for always cheering me on, they continue to be my source of inspiration to do my best.

Last but not the least, my deepest gratitude go to my heavenly father, JEHOVAH, for his grace and mercies, for his love and kindness. He continues to reveal his greatness each step of my journey. I will always put my trust in his perfect will for my life.

CHAPTER 1

1.0 Introduction

This section provides background information surrounding the research topic as well as the rationale of the study. Inclusive in this section is an overview on the workforce in Zambia and the position of the small scale welders in this workforce; welding and welding methods; welding related occupational hazards as well as health effects; preventive measures against welding occupational hazards as well as a synopsis of relevant health and safety laws in Zambia.

1.1.1 Workforce Overview

Workers represent half of the world's population and 70% of this global workforce lives in developing countries [1, 2]. With a total population of 14.4 million, the Zambian working population (i.e. population aged 15 years and older) was estimated at 7.8 million, out of which 5.4 million are employed. More than 80% of those employed in Zambia work in the informal sector [3]. The informal sector comprises mainly of small and medium enterprises (SMEs) which have become central to the poverty reduction strategy and form the fabric on which social and economic stability relies upon [4]. The SMEs are classified based mainly on characteristics such as capital investment, amount of annual revenue or the number of employees. The status of formality is dependent on registration with a tax authority or any other licencing authority in Zambia such as the Local Authority or the Zambia Revenue Authority (ZRA) [3]. These SMEs in Zambia are involved in a wide range of manufacturing (i.e. metal fabrication and food processing) trading (i.e. sale of consumer and agricultural goods) or service activities (i.e. education/training and secretarial services). Inclusive in the SMEs category are welders who among many other activities, are involved in maintenance,

repair and manufacturing of construction materials (i.e. fences, window frames, door frames, gates etc.), auto-mechanic repairs as well as manufacturing of various artisanal articles.

Globally, the welding industry continues to be a critical component of manufacturing [5]. In Zambia, the welding industry is relatively young and lacks the technological advancements observed in many developed countries. The recent growth of the small scale welding industry has been stimulated by increase in construction and manufacturing activities over the past few years which have created a demand for products and services of the small scale welders [6]. Selected training centres (i.e. vocational, industrial and youth resource training centres) in the country train welders primarily as metal fabricators. Qualifications obtained range from diploma and craft certificate (i.e. 2 years study duration) to certificates levels I, II and III (i.e. based on 1 year, 6 months and 3 months study duration respectively) [7]. Geographically, welders in Zambia are found in all parts of the country, but as observed in many other low income countries, they are mostly found in cities where they operate in clusters in market areas, streets or in designated shelters. They are strategically located in areas where people can access their products or in areas where they can easily get calls for repair works or production of various metal works.

1.1.2 Welding and Welding Methods

Welding is an ancient art that has been practiced since man begun to extract and refine iron [8]. Welding is a process that involves the joining of metal pieces by means of a molten flux produced by heat or pressure or both [9]. The process remains the most common method of joining metals in the industry today and is a part of the art of metal fabrication that involves the building of metal structures by cutting, bending and joining. Polishing, painting or coating of the metal pieces also goes along with the other processes to finish the article. Welding types are classified based on the source of heat for melting the metal or filler. The three common sources of heat upon which the classification is grounded are; combustion of a fuel

gas with air or oxygen to produce a flame; an electric arc produced by an electrode between the electrode and work piece; and lastly, electric resistance offered to passage of current between two or more work pieces [9].

Manual Metal Arc (MMA) welding is a type of welding that involves the use of a consumable welding rod coated with a flux; the rod decomposes upon heating and releases shielding gases for the arc - melting the rod and work piece in the process to form a pool of molten metal. The flux on the rod then decomposes to form gases and slag which solidifies and is chipped off the welding upon completion of the task [10]. MMA welding is the most commonly used welding method in the electric arc welding category and is also the most commonly used method in small scale enterprises for reasons that the cost of equipment and maintenance is low compared to other methods [10-12]. In addition, MMA welding equipment is very portable which serves well for small scale welders who at times have to carry their equipment when called for repair jobs - and may also have to move their equipment at the end of a working day. Furthermore, only moderate skills are required to use the equipment, favouring well with most of the workers in small scale enterprises who lack the technical skills required for more specialised welding methods.

Although MMA welding may be more preferable by the small scale welders, it is associated with greater risks of exposure to welding health hazards in comparison to other welding methods. For instance, the amount of fumes and gases produced in MMA welding is higher than other methods such as Gas Metal Arc Welding (GMAW) or Shielded Arc Welding (SAW). When compared to other general-purpose welding electrodes, MMA welding electrodes produce fumes that contain more chemical elements in more than trace (i.e. 1%) amounts. These fumes are largely from the vaporised and decomposed filler and coating. Also because the process of welding using MMA welding is slower compared to other welding methods such as Metal Inert Gas (MIG) welding, the welder may have to spend more

time working on the work piece, thereby increasing their exposure time to fumes and gases [13].

1.1.3 Occupational Hazards and Health Effects Related to Welding

Welding is associated with various inherent occupational hazards [9, 14-16]. These hazards may lead to acute and chronic health effects. Acute health effects are those that usually occur rapidly as a result of short term exposures to hazards, and are of short duration. Chronic effects on the other hand generally occur as a result of long term exposures to hazards and are of long duration [17]. A review of literature showed that there were more studies on chronic health effects – particularly respiratory health effects – compared to studies on acute health effects of welding. Table 1 shows occupational hazards in welding, their sources, acute and chronic health effects as well as welding PPE for prevention of exposure to the hazards.

Various devices are available on the market that can be used by welders to prevent or reduce exposure to welding hazards. The overall goal of PPE is to provide a barrier against hazards i.e. eye and skin PPE or attenuation of the hazard i.e. ear PPE. In the case of respiratory PPE, the protective device either cleans the polluted air to a safe level or provides a stream of uncontaminated air from a separate source [18].

Table 1: Welding Hazards, Their Source, Health Effects and Related Personal Protective Equipment (PPE)

Welding hazards	Source of hazard	Acute health effects	Chronic health effects	Welding PPE
- Fumes and gases	- Welding smoke (Composition dependent on: base metal welded; filler rod materials; coating, paint or grease on surface of work piece; and shielding gases involved).	- Metal fume fever - Irritation of the eyes, nose, chest and respiratory tract. - Transient effect on lung function [9, 19-22].	-Bronchitis, asthma, pneumonia, decreased lung capacity and pneumoconiosis/fibrosis. Associated with lung cancer [13, 19-27]. Skin sensitisation [19].	- Respirators - Face masks - Safety goggles
- Dust	- Grinding activities - Environmental dust			
Intense light [i.e. Ultraviolet (UV) light, visible light and infrared (IR) radiation]	- Welding arc	- Conjunctivitis: ‘welders’ eye’ or ‘arc flash’. - Skin burns (i.e. sunburn effect) [9, 28].	- Loss of eye sight - Conjunctival degenerative disorders [9, 28-30]. - Associated with skin cancer [19].	- Welding helmet - Hand shield - Welding goggles - Safety clothing for skin protection
Noise	- Welding process including allied activities i.e. hammering, grinding and drilling.	- Temporal hearing loss - Stress, annoyance, irritability - Associated with hypertension [31-33].	- Permanent hearing loss - Associated with increased risk of cardiovascular diseases [31-33].	- Ear muffs - Ear plugs
Electrocution/ electric shock	-Welding machine -Other electric powered tools i.e. grinder and drilling machine.	- Burns [9, 15].	- Long term sequelae of electrical injuries including: Neurologic, psychological and ocular effects [34].	- Insulated gloves - Rubber soled safety shoes

Heat	<ul style="list-style-type: none"> - Welding process - Direct sunlight (i.e. if work is done outdoors). 	<ul style="list-style-type: none"> - Burns on exposed skin. - Eye injuries due to hot and flying sparks, slag or metal chips. - Burns in the ear due to hot slag or sparks. - Heat stroke, exhaustion, cramps and rash [9, 35]. 	<ul style="list-style-type: none"> - Long term sequelae like scarring and reduced vision as a result of prolonged exposure. 	<ul style="list-style-type: none"> - Fire resistant clothing and aprons - Ear plugs/muffs
- Fires and explosions	<ul style="list-style-type: none"> - Heat, flames and sparks resulting in combustion of flammable materials (i.e. gas, solvents, paper, wood, plastic). - High pressure gas cylinders (i.e. in gas welding). 	<ul style="list-style-type: none"> - Burns - Physical injuries due to blows from cylinders [9]. 	<ul style="list-style-type: none"> - Long term effects as a result of exposure to explosion gases and fumes, physical injury and/or psychological trauma. 	<ul style="list-style-type: none"> - Fire resistant clothing and aprons - Insulated gloves - Rubber soled safety shoes
- Compressed gases				
- Machinery	<ul style="list-style-type: none"> All machinery with fast moving parts e.g. grinders, drillers and cutters. 	<ul style="list-style-type: none"> - Cuts, lacerations, stabs by sharp edges. - Injections of flying particles into the eyes or skin [9]. 	<ul style="list-style-type: none"> - Hand arm vibration syndrome (HAVs). 	<ul style="list-style-type: none"> - Fire resistant clothing and aprons - Insulated gloves - Rubber soled safety shoes
- Vibrations				
- Ergonomics	<ul style="list-style-type: none"> - Poor work posture - Repetitive work - Heavy lifting 	<ul style="list-style-type: none"> - Musculoskeletal complaints i.e. back pain, muscle fatigue and injuries [9, 15]. 	<ul style="list-style-type: none"> - Carpel tunnel syndrome - Sequelae after injuries 	
- Slips and falls	<ul style="list-style-type: none"> - Working from heights - Poor housekeeping 			

1.1.4 Preventive Measures against Welding Occupational Hazards

Identification of hazards before undertaking any work process is always recommended in the control of hazards in any work setting, to aid the selection of the most suitable preventive measures. Elimination is considered the best way to prevent or control exposure to harmful substances or situations at work, although the method may not always be practical in many work situations. In welding, elimination may involve the removal of the risk factor completely by robotisation of the process – this technique is not well developed yet. Other methods of prevention include engineering controls i.e. local exhaust ventilation; substitution i.e. substitution of welding method and materials with safer options; administrative controls i.e. work-rest schedules and safe work procedures. As the last resort of prevention, when no other approach is feasible, or when the degree of safety achieved by other options is considered inadequate, personal protective equipment (PPE) can be used by exposed workers as means of prevention of exposure to hazards [36].

With regard to welding PPE, protection is required to prevent hazardous exposures from head to toe. For eye and face protection, a welding helmet, hand shield and goggles are required. Eye protection needs to be fitted with the right type of filter lenses to protect the eyes from radiation. Respirators or face masks protect the welder's respiratory system. It is important that the respiratory PPE is fitted with the correct type of cartridge or filter for the chemicals (i.e. welding fumes and gases) or substances (i.e. dust) in the work environment. Exposed skin of the body trunk can be protected by means of fire/flame resistant clothing and aprons. Rubber soled safety boots and insulated gloves protect the welder's feet and hands, respectively. In addition, ear plugs or ear muffs are required to protect the hearing of welders [37] (Also see Table 1). Welding screens can be used to prevent the people working in the same area where welding is taking place from exposure to stray welding arc rays.

Use of personal protective equipment (PPE) entails reliance on active cooperation and

compliance by the worker [36]. Therefore, it is cardinal that the workers are aware of the health hazards present in their work environment and the reason why they should protect themselves. In addition, for PPE to be effective, it is important to ensure that the workers know the right type of PPE to be used and that it is used in the correct way for the periods when the worker is exposed to harmful substances or situations [38].

1.1.5 Health and Safety Laws in Zambia

The absence of policies or regulations that directly address health and safety of welders in Zambia was clearly evident based on a review of literature. In general, self-employed persons and those working in small scale enterprises are covered under the Occupational Health and Safety (OHS) Act, which applies to all places of work in all sectors of the economy. The OHS Act was enacted by an act of Parliament in 2010 to provide for the following: establish the Occupational Health and Safety Institute and its functions; establishment of health and safety committees at workplaces and for the health, safety and welfare of persons at work; duties of manufacturers, importers and suppliers of articles, devices, items and substances for use at work; protection of persons, other than persons at work, against risks to health or safety arising from, or in connection with, the activities of persons at work; and associated matters [39].

Among many other requirements listed in the OHS Act, Part IV outlines duties of employers and self-employed persons to persons other than employees including duties of persons in control of workplaces or plant with regard to prevention of health and safety risks at work. In addition, Part V gives powers to authorised officers under the OHS Act to enter and inspect any premises used as a workplace, or where any person is employed or is about to be employed, which may also include small and medium enterprises [39].

Other pieces of legislation that provide for safety and health of the workers in Zambia include: the Factories Act which is applicable to workplaces defined as factories; the Mining Regulations, applicable to the mining industry; the Ionizing Radiation Act that provides for the protection of the public and workers from dangers arising from the use of devices or materials capable of producing ionizing radiation; the Workers' Compensation Act which provides for the establishment and administration of a Fund for the compensation of workers who are disabled by accidents, or diseases contracted by workers in the course of their employment. Other related laws such as the Public Health Act, Environmental Management Act (i.e. pesticides and toxic substances regulation) and Employment Act also touch on safety and health issues such as provision of sanitary facilities and personal protective equipment for workers [40].

1.2 Study Rationale

The International Labour Organization (ILO) has estimated that over 2 million people die every year from work related accidents and diseases and that over 300 million non-fatal accidents are recorded each year [41]. This translates into more than 6000 deaths and over 800 000 non-fatal accidents every day. In addition, ILO estimated that more than 160 million people suffer from occupational and work-related diseases. In many low and middle income countries such as Zambia, statistics on occupational accidents and injuries are limited, in cases where such information is available it is largely impaired by under reporting. Considering the differences between countries, economic sectors and social groups, it is reasonable to agree that occupational deaths and injuries take a heavy toll among the poor and least protected.

For the small scale welders in Zambia, deliberate policies or measures for delivering health and safety services to this population are limited. This not only limits their access to

information and training opportunities but also places the welders at a greater risk to occupational injuries and diseases. Furthermore, literature has shown that welders in small scale enterprises lack the knowledge on proper use of protective measures and are least aware of health effects emanating from the activities and materials in their work environments [11, 42].

Notwithstanding that personal protective equipment is considered as the last resort for control of hazards in a workplace, to be used only when other possible engineering and management controls have been put in place, it stands out as the most decent measure of protection for welders in small enterprises where conventional occupational safety control principles remain a challenge to implement [38]. Awareness of proper use of PPE, occupational hazards being avoided and the related health effects is therefore cardinal among the welders, lack of which may have an influence on the effectiveness of the PPE.

In Zambia, there is an information gap on welding occupational hazards, level of awareness and utilisation of safety measures as well as prevalence of acute health effects among welders. Such information is vital in understanding the extent of the problem and may be useful when designing intervention strategies targeted at promoting and upholding good health and safety standards in this important working group - hence the study.

CHAPTER 2

2.0 Research Questions and Objectives

This section outlines the research questions and objectives that guided the study.

2.1 Research Questions

- What welding related health hazards are present among small scale welders in Lusaka, Zambia?
- Are the small scale welders in Lusaka, Zambia, aware of the welding hazards to health and the personal protective equipment they should wear during welding?
- What personal protective equipment are small scale welders in Lusaka, Zambia, using during their work?
- What acute health effect related to welding are experienced by small scale welders of Lusaka, Zambia?
- What factors are associated with awareness of health hazards and personal protective equipment, use of personal protective equipment and acute health effects experienced among small scale welders in Lusaka, Zambia?

2.2 General Objective

To gain more knowledge about work and health among small scale welders in Lusaka, Zambia.

2.3 Specific Objectives

1. To describe occupational health hazards among small scale welders in Lusaka, Zambia.
2. To assess awareness of welding health hazards and use of personal protective equipment among small scale welders in Lusaka, Zambia.
3. To describe the use of personal protective equipment among small scale welders in Lusaka, Zambia.

4. To describe the occurrence of acute health effects related to welding among small scale welders in Lusaka, Zambia.
5. To explore associations of factors related to awareness of health hazards and personal protective equipment, use of personal protective equipment and acute health effects experienced among small scale welders in Lusaka, Zambia.

CHAPTER 3

3.0 Methods and Materials

The section details the methods and materials used in the collection, cleaning, processing and analysis of data as well as the ethical considerations taken into account.

3.1 Study Design

This study was descriptive and used a cross sectional design. The cross sectional design was used of to assess factors related to exposure (i.e. welding health hazards, awareness of welding health hazards and personal protective equipment) and outcome (i.e. acute health effects and use of personal protective equipment) at the same time. Other variables were; sex, age, marital status, level of education, type of training, welding work experience, work activities, welding method and length of daily shift. The cross sectional design lent the study a lot of benefits as it is quicker in implementation and costs less compared to other designs such as a cohort study.

3.2 Study Setting

The study was conducted in Lusaka, Zambia. Zambia is a landlocked sub-Saharan country with a land cover of 752 612 square kilometres which is about 2.5 per cent of Africa and has a total population of 14,365,719 as of 2012. Administratively, the country is divided into 10 provinces and 89 districts. The economy of Zambia is a mix of modern urban sector and rural agricultural sector [3, 6, 43].

In addition to being the capital city, Lusaka is also the largest city in Zambia and a major commerce hub of the country. The economic activity in the city is one of the major attracting factors for the small scale welders who are widely distributed geographically and strategically located around the city, operating on road sides and in markets of Lusaka. Therefore, it was expected that Lusaka would provide the required population of welders sought for in the

study.

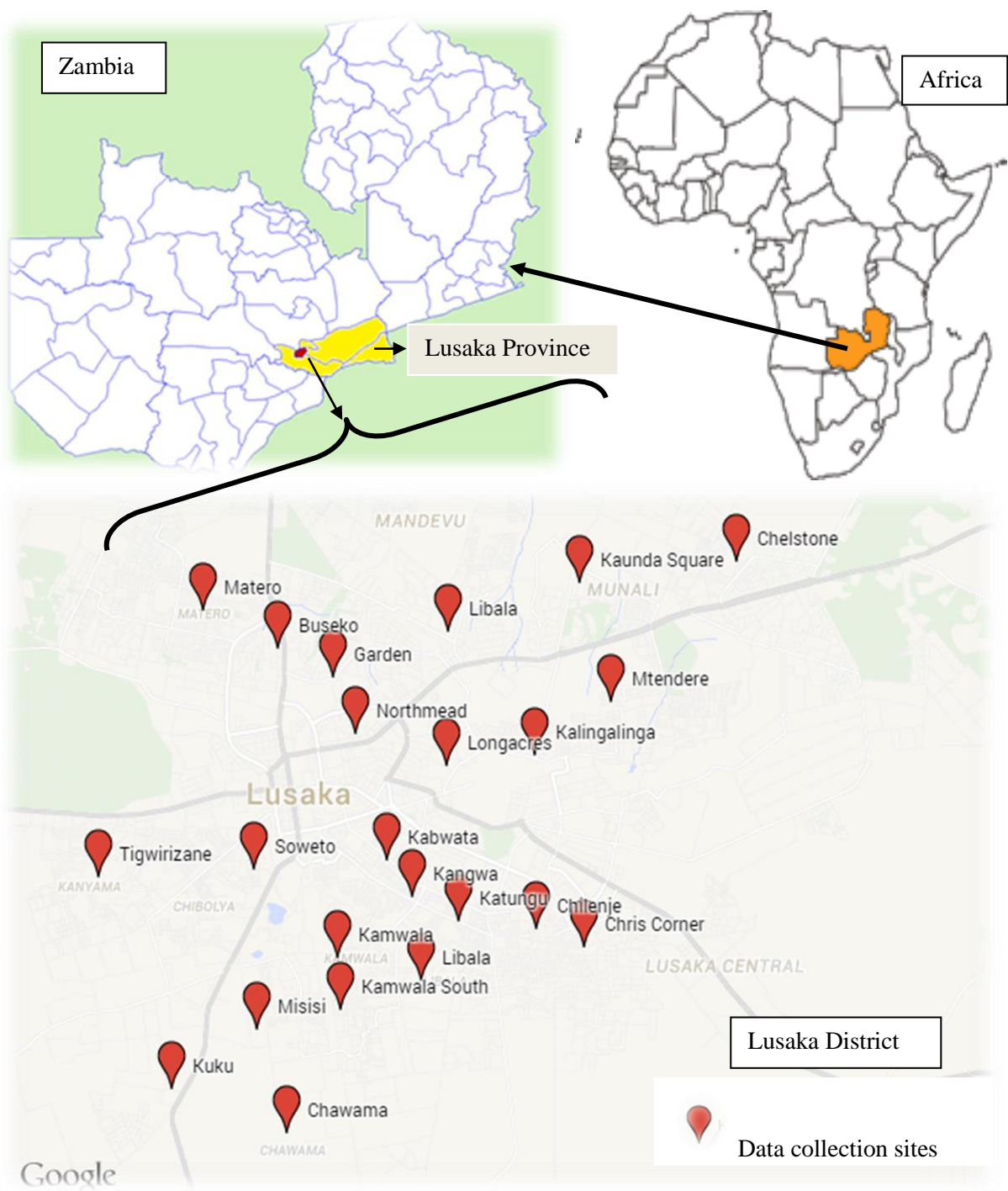


Figure 1: Map of Africa, Zambia and Lusaka District - showing data collection sites

(Adapted from Google Maps)

3.3 Study Population (Inclusion and Exclusion Criteria)

The target population for the study were small scale welders in Lusaka district. Thus, small scale welders operating in market areas and roadsides of Lusaka district were included. The study excluded workers who were not involved in welding, with an exception of helpers and supervisors in the same premises (workshops/stands) where welding activities were taking place, because they were expected to have similar exposures and health effects. Welders who did not give consent to participate in the study were also excluded from the study.

3.4 Sampling and Sample Size

Participants were accessed from their respective operating areas (i.e. markets and roadsides). To start with, a list of markets in Lusaka district was obtained from the Lusaka City Council (LCC), department of housing and social services. A little over 30 markets were identified out of which 27 were operated by the Lusaka City Council. Welders in both markets operated by the Lusaka City Council and those operated by cooperatives were included in the sample. With regard to welders who did not operate in any of the markets (i.e. on roadsides), information from the local authority was used to identify areas where welders operated. In addition, welders in the areas located were asked for information that was used to identify more welders in other areas.

According to the sample size calculation, a total of 430 welders were required for the study. Based on this number, the identified markets and roadside areas were visited, and all welders who gave consent in the different locations were interviewed until the required sample size was attained. Some of the markets identified did not have welders operating in them; hence other markets within Lusaka District were visited. Also, not all roadside premises could make the sample. Considering the geographical distribution of the locations visited, it can be ascertained that the sample was representative for Lusaka District (Figure 1).

Sample size calculation

Going by the sample size calculation for surveys with the confidence interval set at 95% and 5% margin of error, the following sample size was derived:

$$n = \frac{Z^2 P (1 - P)}{e^2} = \frac{(1.96)^2 \times 0.5 (1 - 0.5)}{(0.05)^2} = \frac{0.9604}{0.0025} = 384.16 \approx 385 \text{ participants}$$

Where: P = (expected proportion of welders experiencing acute health effects as a result of work related exposures) = 50% (0.5)¹

e = desired margin of error of 5% (0.05)

Z = Z score at 95% confidence interval = 1.96

Including 10% non-response gave a sample size of 424 \approx 430

Note: ¹ Researchers in Nigeria - a similar setting as the present study - established a proportion of 37.7% for the least common acute health effects among welders due to cuts/injuries by sharp metal edges [44]. Considering that this proportion lies between 10% and 90% extremes, a proportion of 0.5 was used to get the maximum sample [45].

3.5 Data Collection Methods and Tools

Data collection was done by the principal investigator with the help of a research assistant from September to December, 2014. The research assistant - a Bachelor of Science in Environmental Health graduate - was selected based on previous experience in research and data collection from his own research and from studies by others. In addition to experience, the research assistant was provided with adequate information on the goals of the study and the responsibilities of a data collector to ensure that he understood his role in the study. Further, the research assistant was trained both before and during the pilot study on the techniques of collecting the data to ensure that there was consistency.

a. Pilot Study

A pilot study was performed on 10 welders from a market that was not part of the population to be sampled. Both the systematic interview guide and the checklist were tested during the pilot. This was done to determine the effectiveness and credibility of the data collection tools in achieving the objectives and improve the quality of the data collected for the study. After the pilot, adjustments were made where necessary to the data collection tools. For instance, it was observed that it was difficult to differentiate welders' responses to the questions regarding frequency which was in three categories (i.e. always, sometimes and rarely). Therefore, the categories were changed to give only two options (i.e. always or sometimes). Also, it was observed that from the checklist, some of the activities included were not applicable such as sawing and machining, these were removed from the list and replaced with more relevant activities such as painting and cutting.

b. Data collection

Upon arriving at the data collection site (i.e. either market or roadside stand), the management (i.e. person in charge) was approached first before going to the welders. In other instances, the owner (i.e. also the person in charge) was the only welder. The purpose of the study and the population of interest were explained to the management during the introductions. When permission was granted, guidance was sought with regard to location of welding shops/stands. In some instances the management gave a general introduction of the investigators to the welders before the data collection. All welding stands/workshops in the areas visited were considered for inclusion in the study.

Workplace Inspections

A pretested checklist was used during workplace inspections to collect data on work related health hazards and personal protective equipment used (Checklist, Appendix 1B). The checklist was used to take notes on the personal protective equipment mentioned in the

interviews. Also, notes were taken during inspections on general indoor and outdoor work environments and work habits. The checklist was adapted from the welding health and safety assessment tool developed by the Department of Labour of New Zealand as well as the hazard assessment checklist of workplace safety and health hazards developed by the California Department of Industrial Relations [46, 47]. In addition, photographs of personal protective equipment used, work setup, machinery and visible health effect such as burns and injuries were taken with permission. These were used in the report and also shown to the supervisors as observations made during data collection.

Interviews

To ensure privacy and independence of the responses given, the welders were interviewed one at a time, not in a group. The investigators introduced themselves before the interview and asked the participant their language of preference which was the language used during the interview. The purpose of the study and other relevant information for the participants included on the information sheet were read and explained to the participants. If the participants had any questions or concerns regarding the study, these were addressed until the participant was content and convinced with the information provided. Consent was then obtained to participate in the study before collecting any data from them. The participants were asked to sign a consent form as approval of their participation. The participants were given a copy of the information sheet containing the details of the study and contact information of the principal investigator to make contact if they had any concerns or questions after the interview. If any of the welders refused to give consent, they were thanked and the investigators moved on to the next welder until all the welding stands in the area were visited. A copy of the information sheet and consent form was translated to Bemba, one of the common languages used in Lusaka.

During the interviews, a structured interview guide with closed and open ended questions was used to collect data (Interview Guide, Appendix 1A). The questions in the interview guide were designed based on a review of related literature on welding hazards, welding health effects, and welding PPE. This approach of designing the interview guide was used because no standardised questionnaires on the topic were available. The structured interview guide was divided into sections which included demographic and welding training questions (i.e. sex, age, level of education, marital status and type of welding training), occupational exposure related questions (i.e. length of work shift, activities undertaken, welding method used, time spent on welding, products made and materials used) and open ended questions on awareness regarding welding health hazards and personal protective equipment (PPE) use. The interview guide also included questions on what PPE the welders used when working and how often they used the mentioned PPE. In addition, welders were asked about acute health effects/symptoms (i.e. respiratory, nasal, eye and metal fume fever related symptoms as well as cuts and burns) that they had experienced as a result of their work in the preceding two weeks. There are different symptoms of metal fume fever discussed in literature, those used in this study included having a sweet metallic taste in the mouth, flu like symptoms, body chills and fever as well as general body weakness [20, 22, 48]. The instructions and questions in the interview guide were read out to the participants and their responses were entered by the investigator.

3.6 Data Management and Analysis

To ensure quality assurance, the data collected was checked by the principal investigator for accuracy, consistency and completeness on a daily basis after collection. It was then entered in SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0.

Armonk, NY: IBM Corp) for processing and analysis. The questionnaires and checklists were

secured in a safe and locked cabinet. The data was entered without names in the statistical database on a laptop secured with a password only known by the investigator.

Descriptive statistics were used to assess participant characteristics. Quantitative analyses were used to make comparisons by means of Chi square and Analysis of variance (ANOVA) tests for categorical and continuous variables respectively. Chi square analysis was used to assess associations between use of personal protective equipment (PPE) and welders' characteristics which included age, education, training and welding experience. The analysis was guided by the null hypothesis that: There is no difference in use of at least one type of recommended PPE in the different categories of the welders' characteristics.

One way ANOVA analysis was used to compare means of awareness of welding hazards and PPE in the various categories of the welders' characteristics which included age, education and welding experience. The Levene statistic was used to determine homogeneity of the variance and Tukey's Honestly Significant Difference (HSD) test was used in post hoc analyses to identify the groups that were significantly different from the others. The ANOVA analysis was grounded on the null hypothesis that: There is no difference regarding awareness of welding hazards and PPE in the various categories of welders' characteristics.

Generalised Linear Model (GLM) formulation using a binomial model with a log link function was used to derive the Relative Risk (RR) of experiencing acute health symptoms/effects between welders who reported using personal protective equipment (PPE) and those who reported not to use PPE. The null hypothesis that guided this analysis was that: There is no difference in risk of experiencing acute health symptoms/effects between welders who used PPE and those who did not. Separate analyses were conducted for each of the symptoms/effects with their related PPE. Age was controlled for as a likely confounder, among the welder's characteristics, but there was minimal or no change in the parameter

estimates hence unadjusted estimates were presented. Smoking was adjusted for in the analyses involving experienced acute respiratory and nasal symptoms.

A cut-off point of $p \leq 0.05$ was used to determine significance in all quantitative analyses.

3.7 Ethical Consideration

In order to ensure justice in the study, all welders in the selected areas were invited to participate in the study. Participants were guaranteed the autonomy to take part in the study and all data collected was kept confidential. No information concerning individuals would ever be available for anyone but the researchers. However, the participants were informed that summarised and anonymous results of the study would be shared with relevant stakeholders - at group level only - to ensure maximum benefit to the study participants. In addition, ethical clearance was obtained from the Norwegian and Zambian Ethical Review Bodies (ERB).

CHAPTER 4

4.0 Results

Welding Locations

In total, 23 locations in which welders operated were visited during data collection (Table 2). The largest number of welders were located in Garden (n = 87, 20%), which is also one of the oldest known locations for welding work in Lusaka. Areas occupied by welders were situated in markets, roadsides and residential areas. Welders operated mostly on road sides, the welding stands/shops for those in markets were also commonly located on the roadsides of the markets.

Table 2: Welding Locations and the Respective Number of Welders

Location	(n)	(%)
Katungu	04	1
Kangwa	04	1
Longacres	04	1
Northmead	06	1
Kamwala	06	1
Kaunda Square	07	2
Libala	08	2
Chris Corner	09	2
Mtendere	09	2
Kabwata	10	2
Fridays Corner	13	3
Kamwala South	13	3
Chilenje	16	4
Chawama	16	4
Misisi	17	4
Chelstone	20	5
Tigwirizane	21	5
Matero	21	5
Kuku	22	5
Buseko	33	8
Kalingalinga	40	9
Soweto	44	10
Garden	87	20
Total	430	100

The lack of planning in the premises occupied by the welders was evident in the locations visited, most of which had no properly planned facilities for the welders. In all locations visited, welders operated in clusters, and the majority did their work in open areas (Figure 2). The shops/stands in the markets were used more for storage than for the actual welding work.



Figure 2: Work Areas for Welders

Structures used as workshops ranged from permanent concrete wall structures to simple and temporal shades of metal or wooden framework with polythene, cardboards or iron sheet roofing to provide shade (Figure 3). Also in use were bulk metal containers and lockable stainless steel bar cages for storage of materials and products.

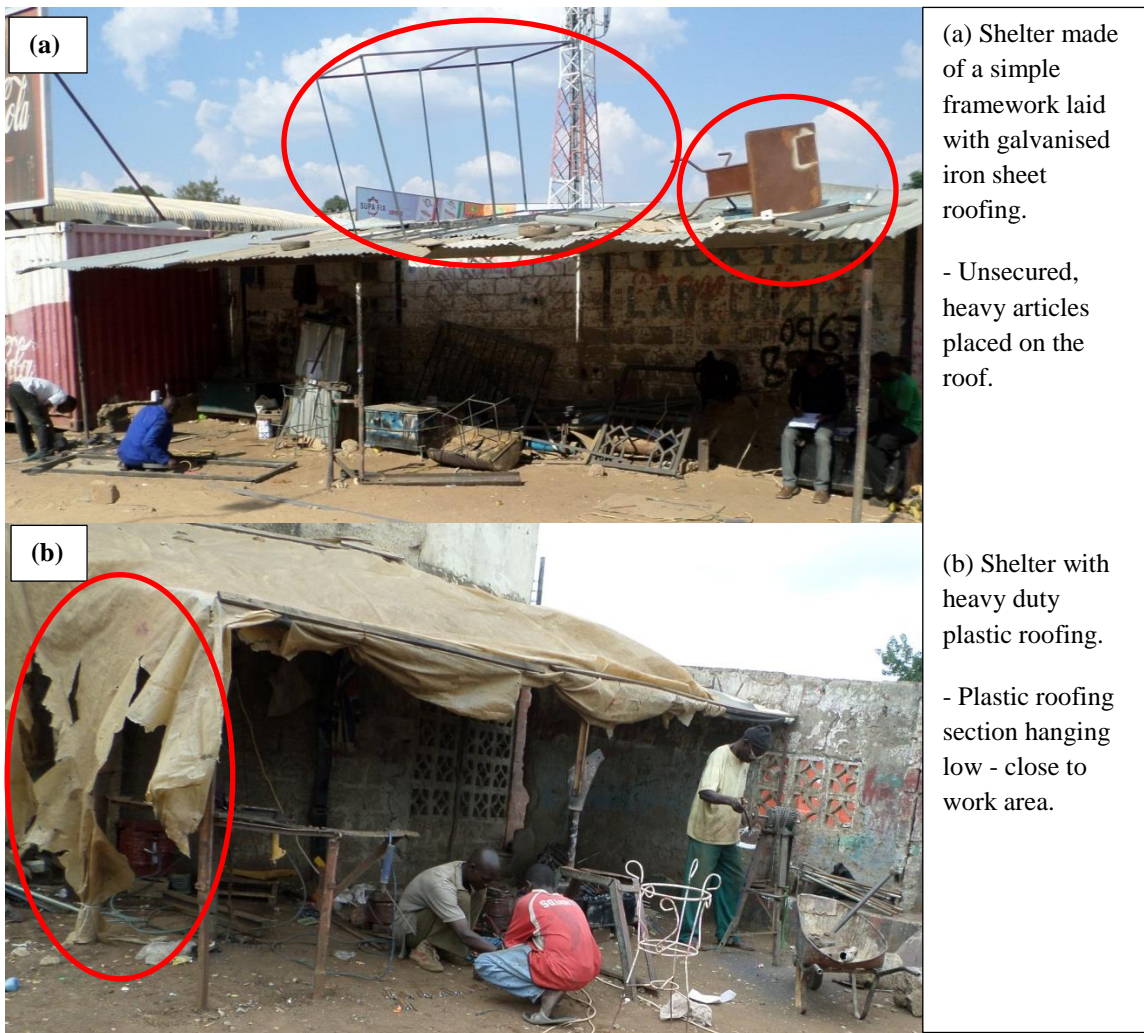


Figure 3: Shelters Used By Welders

Welding Machines Used

Manual Metal Arc (MMA) welding machines used by welders were simply crafted and hand made. The MMA welding machines comprised of a transformer (made of coiled copper wire), two lead cables (i.e. one for the work piece and another for the electrode), a ground/work clamp and an electrode holder. Three of the welders (1%) were found using conventional electric arc welding machines. Figure 4 depicts the welding machines used by the electric arc welders.

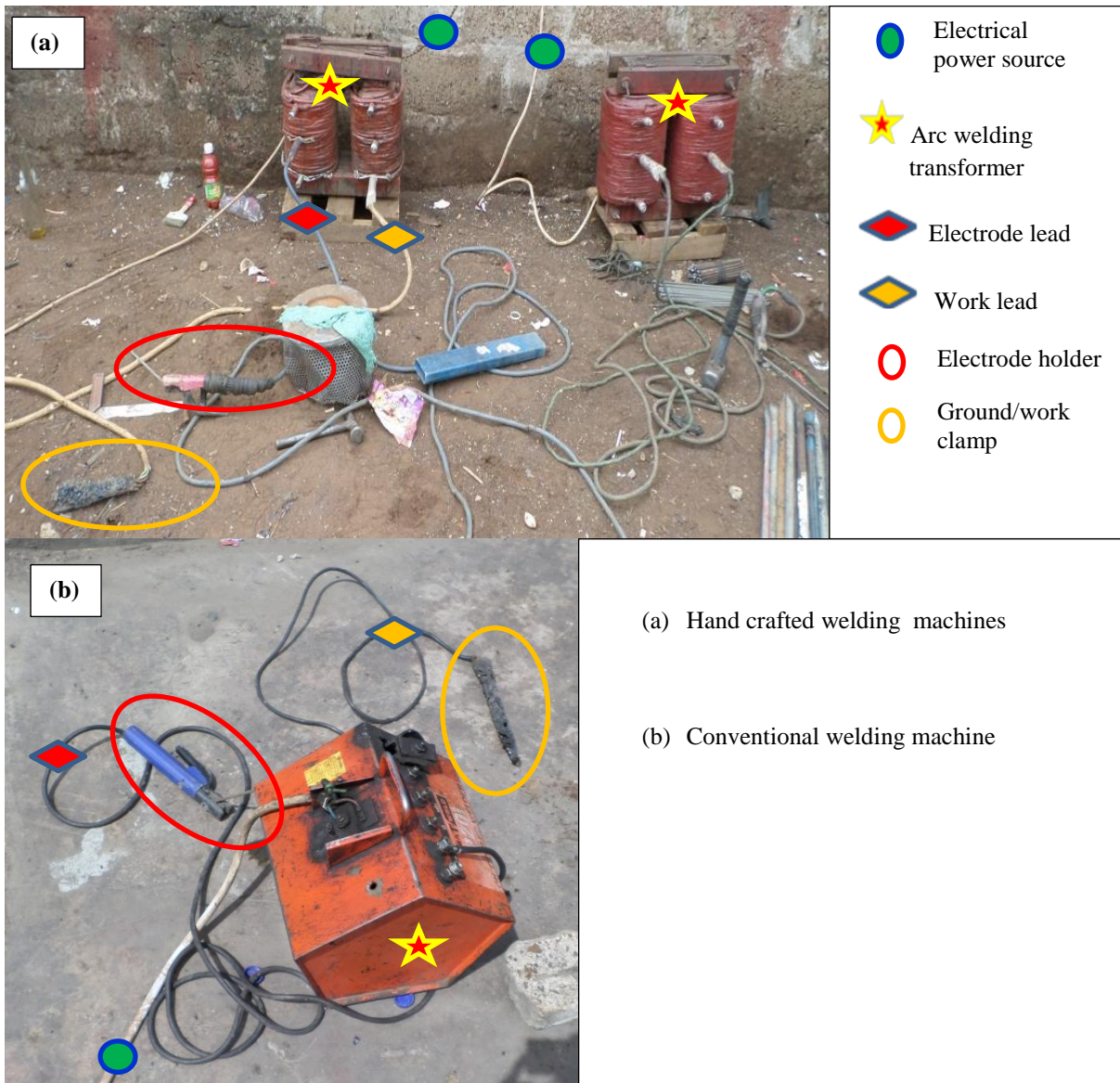


Figure 4: Manual Metal Arc Welding Machines Used

For gas welding, the welding equipment comprised of two gas cylinders (i.e. acetylene and oxygen) and two hoses connecting the gas to the welding torch. Not many cylinders were mounted on cylinder supports (Figure 5). In addition to welding, common activities observed among welders were grinding, cutting, hammering and painting. This involved the use of machinery such as electric grinders and drills; manual cutters and bending equipment.

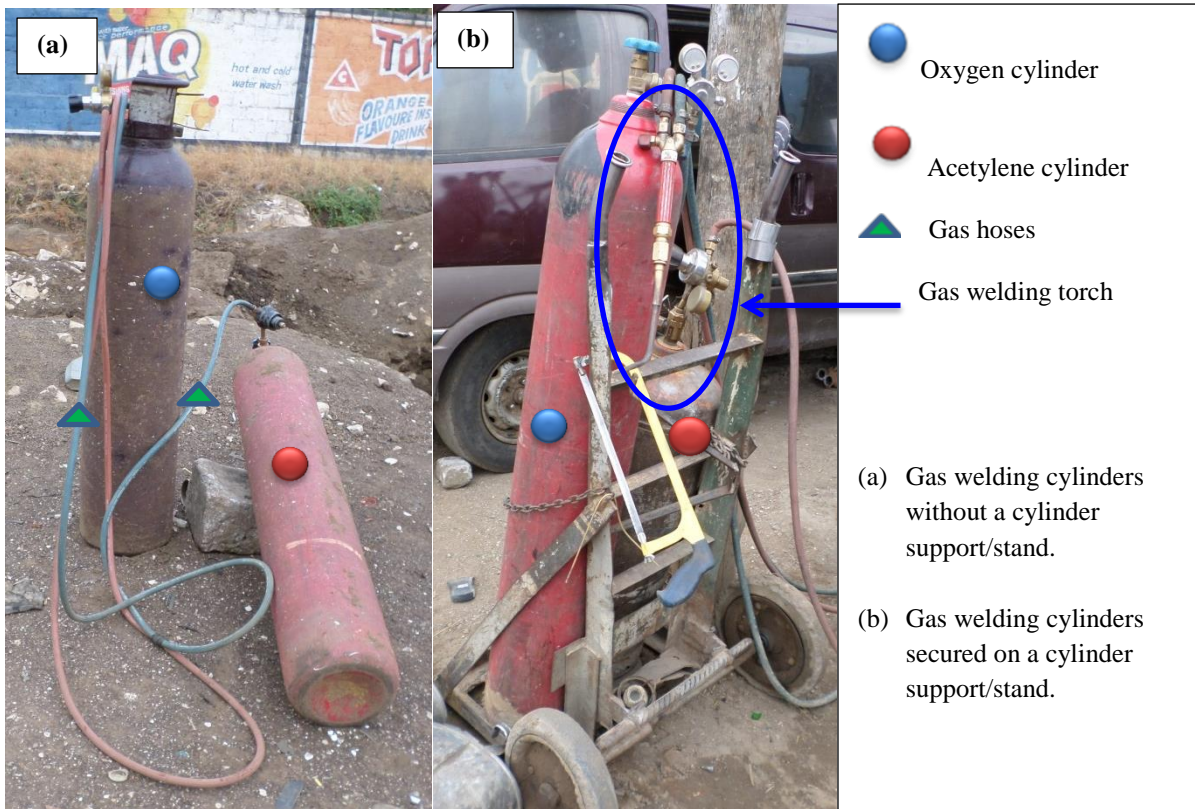


Figure 5: Gas Welding Equipment

Materials Used and Products Made

Materials observed and reported to be in use during data collection were stainless steel, mild steel, galvanised iron, cast iron and aluminium. In addition to repair works, welders mentioned that they were able to make almost anything according to their client’s needs and demands with the available materials. The products that welders in the visited areas had made included a range of construction fixtures such as door and window frames, metal doors, gates, burglar bars and tank stands (Figure 6). Others included decorative art pieces for both interior and outdoor décor. Welders also made cooking braziers, popcorn machines, food warmers, swings, slides, chairs and tables to mention just a few (Figure 6).



Figure 6: Some of the Products Made By Welders

Welding Related Hazards Observed

A number of welding and welding related activity hazards were observed in the data collection sites. In all sites, airborne dust/fumes and gases, flying particles, intense light, extreme heat as well as vibration and noise hazards were observed. Figure 7 illustrates some of the hazards observed.



Figure 7: Welding Related Hazards Observed

- Notes: (a) and (b) Welders exposed to smoke, intense light and heat from welding.
- Skin exposed to heat, Ultraviolet radiation and physical injury.
(c) and (d) Welders exposed to flying particles, noise and vibration from hand held tools.
(a), (c) and (d) Welders working in poor ergonomic postures.

Vibration hazards were observed for welders using manual metal arc welding method, as well as during work involving vibrating hand held tools such as grinders. The process of welding produced uncomfortable noise levels especially when the work involved hollow work pieces or thin flat metal sheets. Activities involving hammering and grinding produced noise levels that hindered normal conversation and was also very uncomfortable to the ears. In addition, mixed exposures to wood dust were observed in locations such as Buseko, Tigwirizane, Matero and Kalingalinga where welders worked in the same premises as carpenters. In Chilenje, Soweto and Long Acres, welders worked in the same area as those who did brake-bonding, a process which may cause asbestos dust exposure - among many other hazards.

General Work Environment Hazards Observed

Work areas visited were well lit owing to the fact that work was conducted in open spaces with adequate natural light. The open work spaces provided natural ventilation in the work areas. However, the open work spaces also exposed workers to physical environment elements such as heat from the sun, dust from the surrounding and rain water during the wet season (Figure 8). The work tasks were mainly done manually and involved heavy lifting of materials and products made. Work areas were not orderly or tidy – cables, tools and materials were haphazardly arranged in work areas, cut offs and domestic waste (i.e. papers, plastics and empty bottles) littered work areas. In all areas visited, welding electrodes were left lying on the ground or worktables, they were not removed from electrode holders and electrode holders were not placed in insulated hungers as recommended. Paint and paint thinners were common hazardous materials/chemicals observed to be in use for which material safety data sheets were not available. Flammable materials were a hazard for welding involving motor vehicles with petroleum fuel tanks. Also, gas cylinders used in gas welding were a source of flammable gas - if not handled properly they may cause fire accidents. Gas cylinders were not properly labelled or secured and pressure gauges and

regulators were not functional for most gas cylinders (Figure 8.c). The welding work was conducted very close to the gas cylinder which further increased the risk of fires or explosions (Figure 8.c). Figure 8 illustrate some of the hazards observed.



Figure 8: Work Environment Hazards Observed

Notes: (a) Welder exposed to physical environment elements i.e. dust, heat (from the sun).

(b) Untidy work area – poor housekeeping.

(c) Unsecured gas cylinders, loose cables in work area.

- Cylinders placed close to source of heat i.e. burning welding torch.

There were no screens or shields provided during welding to prevent exposure to other workers or the general public - considering that work was done on road sides and open areas. In addition, no safety signs or placards were available in all work areas visited at the time of data collection. No first aid or fire extinguishing equipment was available in any of the locations visited. Welders were observed to work in poor ergonomic positions and the untidy work areas with chaotically placed cables which posed a risk of slips and falls. Road traffic was also a hazard for welders working on roadsides. Figure 9 illustrate some of the electrical hazards observed.



Figure 9: Electrical Hazards Observed

Storage and Maintenance of Personal Protective Equipment

In all work areas visited, there was no proper provision for storage of personal protective equipment (PPE); most of the PPE (i.e. welding helmets, goggles, gloves, ear muffs) was left lying on the ground or work tables or clustered cabinets when not in use. PPE observed to be in use was in poor state of maintenance, for instance, all welding helmets had missing head bands/straps. Shields and goggles had broken and/or missing filter lenses. Respirators and face masks had missing filters. Work suits/coveralls for some welders were covered in grease. A depiction of PPE used by the welders is given in Figure 10.



Figure 10: PPE Used by Welders

Demographic and Work related Profile of Welders

A total of 430 welders were interviewed of which only 3 (1%) were female, the rest were males (Table 3). The age of welders ranged from 16 to 74 years with an average age of 33 years (Standard Deviation = 10 years). The majority of the welders were married (n = 298, 69%, Table 3) and had received at least primary school education (n = 225, 52%, Table 3). Overall, 16% reported that they presently smoked at the time of data collection (Table 3). Six of the welders approached refused to participate in the study. Three for reasons that they were busy, others mentioned that they did not believe that research would help with the challenges that they were facing in their work.

Table 3: Demographic Characteristics of Welders (n = 430)

Welders' characteristics	(n)	(%)
Sex		
Male	427	99
Female	3	1
Age¹		
< 28 years	135	31
28 to 36 years	154	36
>36 years	140	33
Mean (SD)	33 (10)	
Marital status		
Single	119	28
Married	298	69
Divorced	9	2
Widowed	4	1
Level of education		
None	19	4
Primary and basic	225	52
Secondary and higher	186	43
Smoking		
Currently smoking	69	16
Quit Smoking	113	26

¹ Age in tertiles (i.e. three equal groups)

SD = Standard deviation

Most welders (n = 369, 86%, Table 4) reported having learnt how to weld from fellow skilled and experienced welders. The welders' work experience ranged from 4 days to 44 years with a mean of 9 years (SD = 8 years). Majority of the welders reported to work for long hours (i.e. more than 8 hours a day) (n = 386, 90%, Table 4). Half of the welders spent more than 7 hours of their time welding. The common welding method used was manual metal arc welding (n = 380, 88%, Table 4).

Table 4: Work Related Descriptive Characteristics of Welders (n = 430)

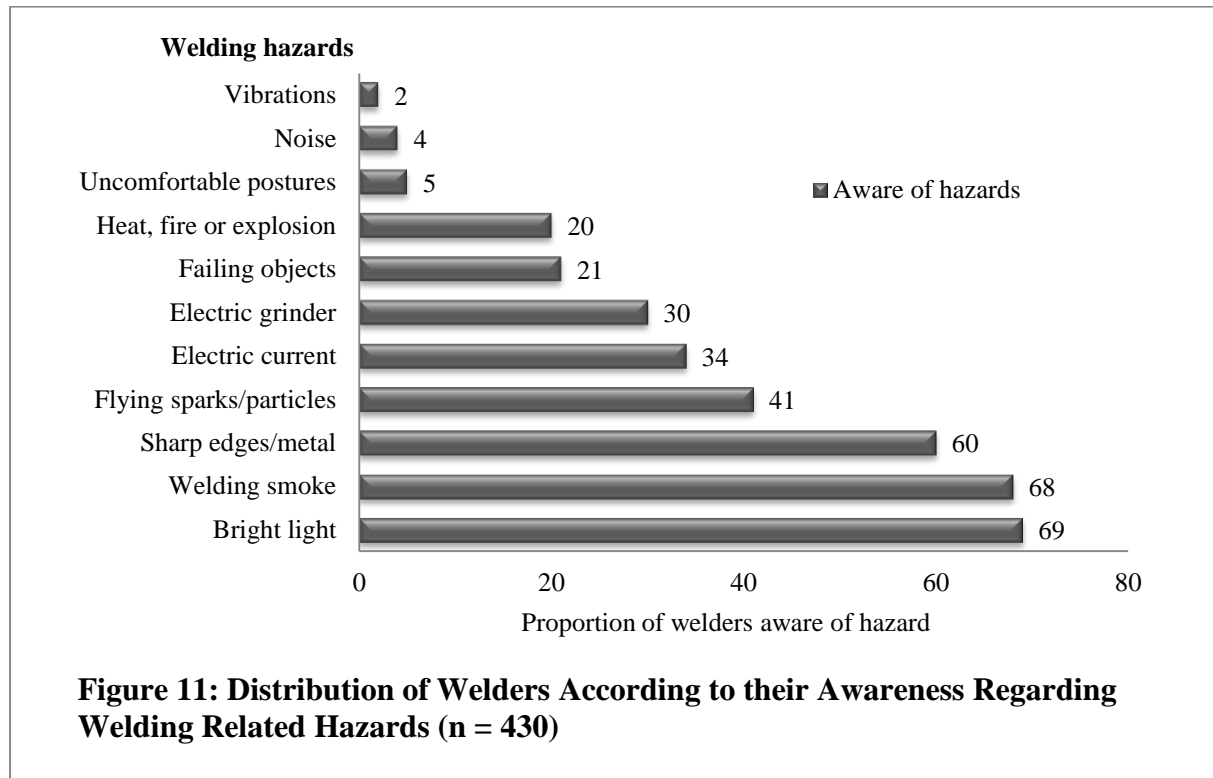
Welders' characteristics	(n)	(%)
Type of training		
Apprenticeship	369	86
Technical	61	14
Work experience¹		
< 4 years	147	34
4 to 10 years	146	34
> 10 years	137	32
Mean (SD)	9 (8)	
Length of work day		
8 hours	44	10
> 8 hours	386	90
Time spent welding		
≤ 7 hours	216	50
> 7 hours	214	50
Welding method used		
Manual Metal Arc Welding	380	88
Gas Welding	25	6
Both	25	6

¹Work experience in tertiles (i.e. three equal groups)
SD = Standard deviation

Awareness Regarding Welding Related Hazards

When welders were asked what they knew could cause harm or injury or cause them to become sick as a result of welding, it was revealed that more than half of the welders were

aware of bright light, welding smoke and sharp edges/metals. This meant that about one third of the welders were not aware of these hazards. In addition, with proportions of 5% and less, welders were less aware of vibrations, noise and uncomfortable work postures as hazards related to their work (Figure 11).



Awareness Regarding Personal Protective Equipment (PPE)

When welders were asked what personal protective equipment (PPE) they knew they could use when welding, the majority of welders were aware of safety shoes (87%), work suit/coveralls (68%), welding goggles (66%) and safety gloves (57%). Overall, welders were least aware of respiratory (25%) and ear protection (10%).

Total Scores Regarding Awareness of Welding Related Hazards and Personal Protective Equipment

When the responses to questions regarding awareness of welding related hazards and PPE were summed up to sum scores for welding hazards and PPE, for each of the study

participants, it was revealed that 98% of the welders were aware of at least one welding related health hazard or type of PPE. However, about 2% (n = 7) of the welders were not aware of any health hazards related to their work or any PPE that they could use when welding. The sum for both awareness regarding welding hazards and PPE was from 0 (no awareness) to 8 (highest awareness). Based on this range, three categories were created to represent low (total score of 0 - 2), medium (total score of 3 - 5) and high (total score of 6 - 8) level of awareness regarding welding hazards and PPE. The majority of welders had medium level of awareness regarding PPE (n = 305, 71%, Table 5) and welding hazards (n = 271, 63%, Table 5). Overall, the proportion of welders with low level of awareness was highest for welding related hazards (26%) compared to PPE (17%).

Table 5: Sum Scores for Awareness Regarding Welding Hazards and Personal Protective Equipment (PPE) (n = 430)

Score ¹	Welding hazards		Welding PPE	
	(n)	(%)	(n)	(%)
Low				
0	7	2	7	2
1	29	7	27	6
2	73	17	39	9
Total	109	26	73	17
Medium				
3	105	24	106	25
4	111	26	121	28
5	55	13	78	18
Total	271	63	305	71
High				
6	28	7	32	7
7	19	4	15	4
8	3	1	5	1
Total	50	12	52	12

¹ Sum score of welding hazards and PPE the welder was aware of.

Associations of Welders' Characteristics with Awareness Regarding Hazards and Personal Protective Equipment

A comparison of welders awareness of welding hazards (i.e. ranging from 0 to 8) in the three categories of level of education of welders showed a difference between the groups (One way ANOVA, $p = 0.05$, Table 6). Using Tukey's Honestly Significant Difference (HSD) post hoc analysis to identify which of the groups were significantly different from the other, it was found that those who were illiterate were less aware of welding hazards compared to those who were literate ($p = 0.089$). There were no statistically significant differences observed neither between welding hazard awareness and age nor between welding hazards awareness and years of experience. However, mean scores for hazard awareness decreased with increase in welding experience (Table 6). Appendix 2A shows the summary of ANOVAs of the association.

Table 6: Summary of Means for Associations between Awareness Regarding Welding Related Hazards and Welders' Age, Education and Welding Experience

Welders' Characteristics	N	Mean	SD	P - value
Age				
< 28 years	135	3.56	1.51	
28 to 36 years	154	3.55	1.66	0.89
> 36 years	140	3.63	1.56	
Level of education				
Illiterate	19	2.95	1.39	
Primary and basic	225	3.47	1.50	0.05
Secondary and higher	186	3.75	1.68	
Welding experience				
< 4 years	147	3.68	1.52	
4 to 10 years	146	3.62	1.65	0.28
> 10 years	137	3.39	1.57	

N = Number of welders in each category

SD = Standard Deviation

In bold = Significant at $P \leq 0.05$

Similarly, the results showed differences in PPE awareness (i.e. ranging from 0 to 8) by level of education (One way ANOVA, $p = 0.03$, Table 7). Post hoc analysis using Tukey's HSD test indicated that the mean scores for those with primary and basic education differed from those with secondary and higher education ($p = 0.058$). Overall, the results indicated that there was an increase in mean awareness levels regarding PPE with increase in level of education. Although the differences were not statistically significant, mean scores for PPE awareness increased with an increase in age (Table 7). Appendix 2B outlines the summary of ANOVAs for this association.

Table 7: Summary of Means for Associations between Personal Protective Equipment (PPE) Awareness and Welders' Age, Education and Work Experience

Welders' Characteristics	N	Mean	SD	P - value
Age				
< 28 years	135	3.61	1.53	
28 to 36 years	154	3.81	1.63	0.15
> 36 years	140	3.98	1.45	
Level of education				
Illiterate	19	3.37	1.54	
Primary and basic	225	3.66	1.47	0.03
Secondary and higher	186	4.01	1.60	
Welding experience				
< 4 years	147	3.69	1.61	
4 to 10 years	146	3.86	1.52	0.59
> 10 years	137	3.85	1.49	

N = Number of welders in each category

SD = Standard Deviation

In bold = Significant at $P \leq 0.05$

Personal Protective Equipment (PPE) Used by the Small Scale Welders

The most commonly used PPE reported by welders were work suits/coveralls ($n = 288$, 67%, Table 8) and safety boots ($n = 247$, 57%, Table 8). In contrast, ear and respiratory PPE had the lowest frequencies of reported PPE use (6% and 16% respectively, Table 8). Welders also reported to use protective equipment not recommended for their use. For instance, the

majority (n = 327, 76%) of welders reported to use sunglasses as eye protective equipment, others reported working in ordinary shoes (n = 225, 52%) and ordinary clothes (n = 221, 51%) (Table 8).

Table 8: Personal Protective Equipment (PPE) Used By Small Scale Welders in Lusaka, Zambia (n = 430)

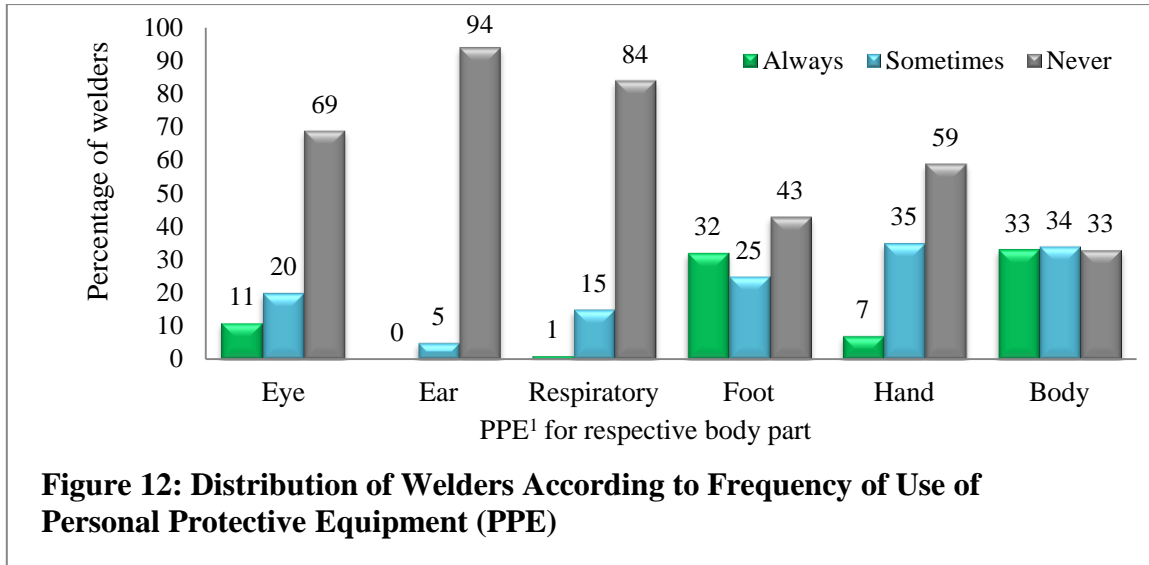
PPE used¹	(n)	(%)
Eye protection		
Sun glasses ^x	327	76
Safety goggles	86	20
Welding shield	66	15
Welding helmet	13	3
Ear protection		
Ear muffs	13	3
Ear plugs	10	2
Respiratory protection		
Face mask	44	10
Respirator	26	6
Foot protection		
Safety boots	247	57
Ordinary shoes ^x	225	52
Wellington boots ^x	8	2
Hand protection		
Leather gloves	177	41
Rubber gloves ^x	16	4
Body protection		
Work suit/coverall	288	67
Ordinary clothes ^x	221	51
Apron	2	1

Note: Welders used more than one type of the respective PPE.

^x This Personal Protective Equipment (PPE) is not recommended for use by welders (included for descriptive purposes only).

¹ Used either sometimes or always.

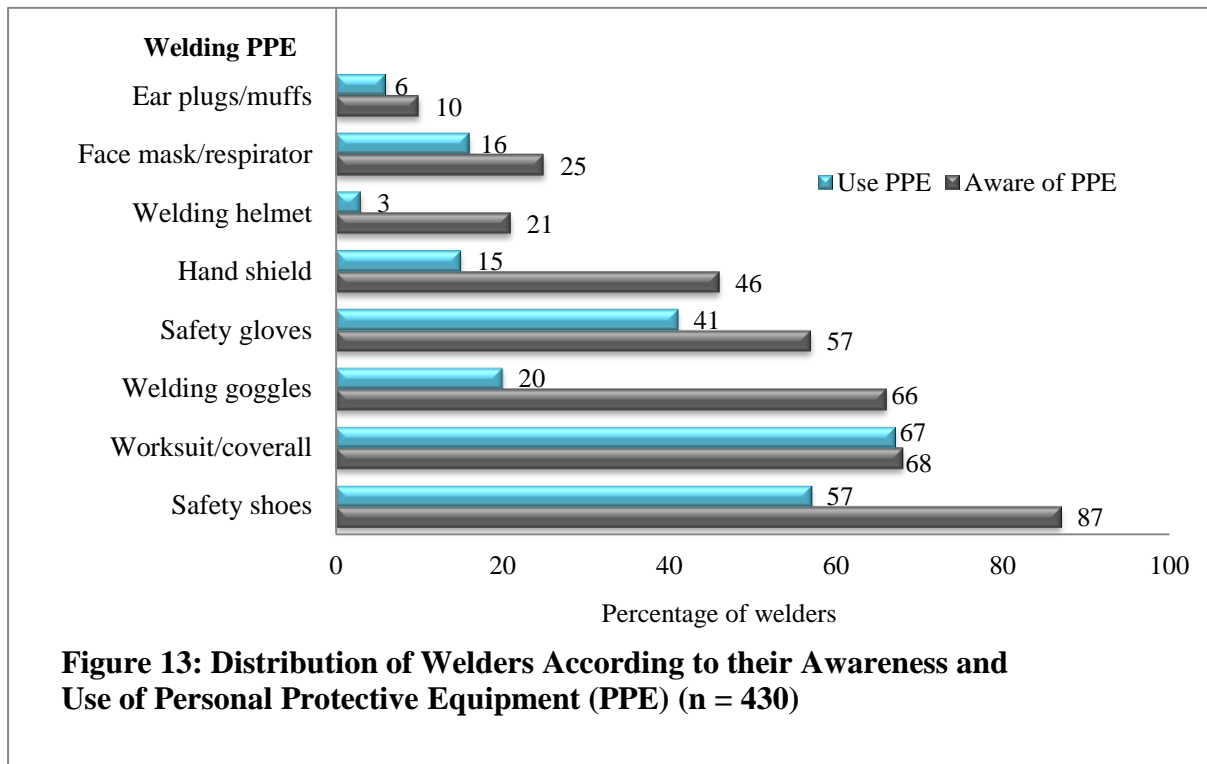
Body and foot personal protective equipment had the largest proportions (33% and 32% respectively, Figure 12) of welders reporting to always use the PPE when welding. In contrast, more than 50% of welders reported to have never used any of the recommended ear, respiratory, eye or hand PPE when welding (Figure 12).



¹ At least one type of recommended PPE

Awareness and Use of Personal Protective Equipment (PPE)

Discrepancies between awareness and use of the PPE were observed (Figure 13). More than 10% of the welders who reported to have been aware of the welding helmet, shield, goggles, gloves and shoes as welding PPE reported not to use it. Figure 13 shows the distribution of welders according to their awareness of PPE and use of the mentioned PPE.



Note: PPE use included those who used the PPE always and sometimes

Associations between Welders' Characteristics and Use of PPE

The proportion of welders using at least one type of PPE was least in the youngest participants (< 28 years) (Chi square test, $p = 0.03$, Table 9). Also, Welders with no education had the least proportion reporting to use PPE, compared to those with primary and higher education (Chi square test, $p = 0.01$, Table 9). Furthermore, the proportion of welders reporting to use PPE increased with an increase in work experience (Chi square test, $p = 0.05$, Table 9).

Table 9: Relationship between Welders' Characteristics and Use of Personal Protective Equipment (PPE) At Work among Small Scale Welders in Lusaka, Zambia

Welders' characteristics	Welders using PPE ¹		
	n (%)	Total	P value
Age (years)			
< 28 years	107 (79)	135	
28 to 36 years	132 (86)	154	0.03
> 36 years	127 (91)	140	
Level of education			
Illiterate	11 (58)	19	
Primary and basic	194 (86)	225	0.01*
Secondary and higher	162 (87)	186	
Training			
Apprenticeship	311 (84)	369	0.17
Technical	56 (92)	61	
Welding experience (years)			
< 4	117 (80)	147	0.05
4 to 10	128 (88)	146	
> 10	122 (89)	137	

Note: All p values were calculate using chi square test

¹ At least one of the recommended PPE, used either always or sometimes

*P value calculated using Fishers exact test

In bold = Significant at $P \leq 0.05$

Occurrence of Acute Health Effects Related To Welding Among Welders

The most common acute health effects reported to have been experienced during the two weeks preceding the interview were burns on the hands/arms (n = 376, 87%) followed by red itchy (n = 366, 85%) and running eyes (n = 357, 83%) respectively (Table 10). Overall, the majority of welders had experienced at least one of the acute health effects asked for in the study related to the eyes (n = 377, 88%), nasal (n = 336, 78%) and respiratory (n = 276, 64%) system. Burns (n = 380, 88%) and cuts (n = 342, 80%) on the hands/arms, body or feet were also common. Figure 14 illustrates some of the acute health effects observed during data collection.

Table 10: Acute Health Effects Experienced by Welders (n = 430)

Acute Health effects	(n)	(%)
Respiratory symptoms		
Cough	269	63
Shortness of breath	183	43
Wheezing	72	17
Nasal Symptoms		
Stuffy nose	256	60
Running nose	299	70
Sneezing	306	71
Eye Symptoms		
Running eye	357	83
Red itchy eyes	366	85
Foreign particles in the eye	335	78
Cuts on;		
Hands/arms	340	79
Body trunk	29	7
Feet	57	13
Burns on;		
Hands/arms	376	87
Body trunk	101	24
Feet	92	21
Symptoms of MFF¹	291	68

¹ MFF = Metal Fume Fever

Note: - Symptoms of MFF was defined as having experienced all related symptoms at the same time after welding (i.e. sweet metallic taste in the mouth, flu like symptoms, body chills and fever as well as general body weakness).

- Welders had more than one symptom related to the acute health effects asked for.

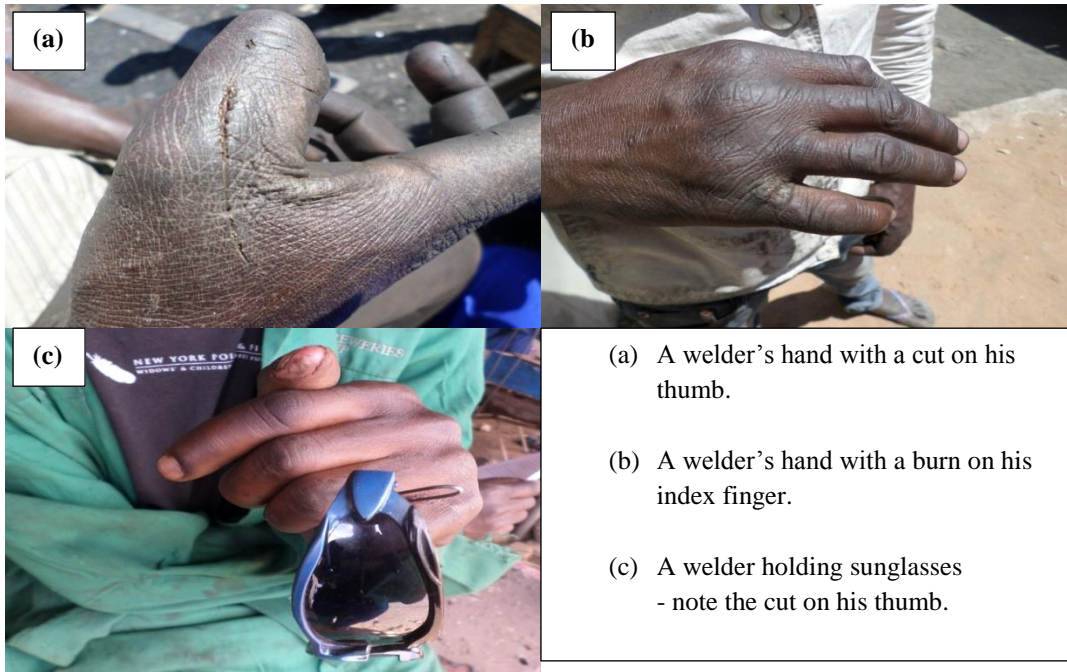
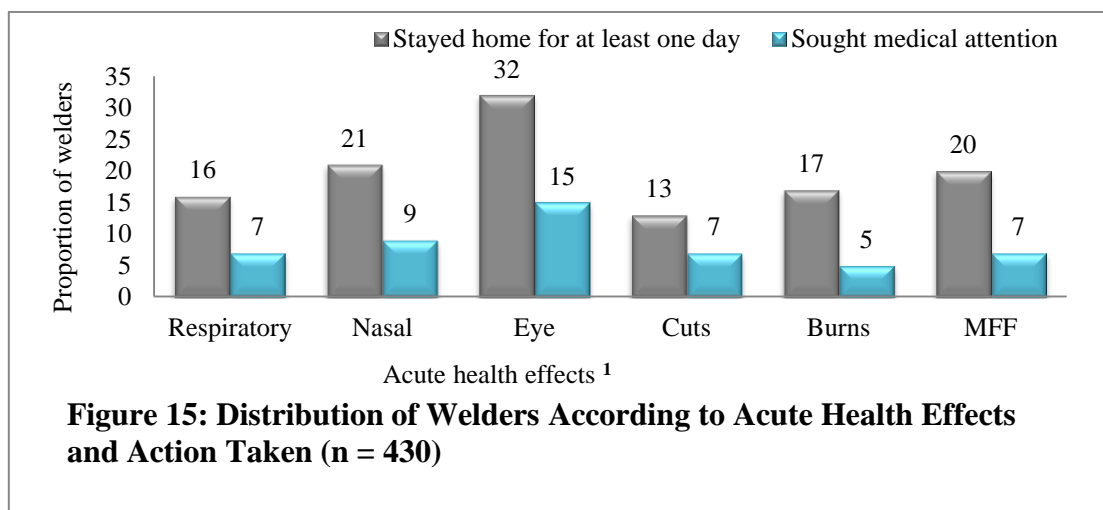


Figure 14: Acute Health Effects Observed

Action Taken in Response to Acute Health Effects Experienced

Among those who had experienced health effects during the last two week preceding the interview, effects on the eyes were the common (32%) health problems causing welders to stay home for at least one day (Figure 15). Eye related health problems also resulted in the highest (15%) proportion of welders seeking medical attention. All the health effects asked for in the study had caused the need for welders to seek medical attention or stay home for at least one day (Figure 15).



MFF = Symptoms of metal fume fever ¹ At least one of the related acute health effects

Association between Occurrence of Acute Health Effects and Use of Personal Protective Equipment (PPE)

It was revealed that there was a 35% (Table 11) decrease in risk of experiencing cuts and/or burns on the feet for those who used foot protection compared to those who did not use the PPE. In contrast, those who used body and respiratory protection were more likely to experience acute health effects compared to those who did not use the related PPE. For instance the risk of cuts and burns on the body was 2 times higher (CI = 1.32 – 3.00, Table 11) in those who reported to use body PPE than in those who reported not to use it. Overall, there was almost no difference (i.e. RR = 1) in experiencing acute health effects between those who used PPE and those who did not.

Table 11: Relationship between Acute Health Effects and Use of Personal Protective Equipment (PPE)

Acute health symptoms/effects	PPE ¹ Use at Work [n (%)]		RR	95% CI	
	No	Yes			
Eye PPE					
Eye symptoms	Yes	260 (88)	117 (87)	0.99	0.92 – 1.07
	Total	296	134		
Hand PPE					
Cuts and burns on hands	Yes	232 (92)	158 (89)	0.97	0.91 – 1.04
	Total	253	177		
Body PPE					
Cuts and burns on body	Yes	23 (16)	93 (32)	1.99	1.32 – 3.00
	Total	142	288		
Feet PPE					
Cuts and burns on feet	Yes	64 (35)	56 (23)	0.65	0.48 – 0.88
	Total	183	247		
Respiratory PPE					
Respiratory symptoms	Yes	226 (62)	50 (74)	1.18 ^a	1.00 – 1.38
	Total	326	68		
Nasal symptoms	Yes	278 (77)	58 (85)	1.12 ^a	1.00 – 1.26
	Total	326	68		

¹ At least one type of PPE
RR = Relative Risk

^a Adjusted for smoking
CI = Confidence Interval

CHAPTER 5

Discussion

In this study, a number of occupational hazards were observed in the welders' work environments. The majority of welders were aware of at least one type of welding hazard and PPE respectively. However, there were others who were not aware of anything related to their work that was harmful or of any personal protective equipment that they could use. The self-reported prevalence of acute health effects was high for eye, nasal, respiratory and metal fume fever related symptoms as well as for cuts and burns on hands/arms. The reported use of PPE did not seem to offer protection for most of the associated hazards as marginal differences in the risk of experiencing acute health effects were observed between those who reported to use PPE and those who did not use it. Education was positively associated with awareness of both welding hazards and PPE as well as with the use of PPE.

Welding Occupational Hazards

In this study, several welding and welding related hazards were observed in the welders' work environments which included fumes and gases, dust, intense bright light, noise, vibrations, electricity, intense heat as well as hazards from unsecured gas cylinders, work postures and fast moving machinery such as grinders. These are well documented occupational hazards inherent to welding and allied processes [9, 14, 15, 19, 49, 50]. The present study found that Manual Metal Arc (MMA) welding was the method used by most welders. This finding on MMA welding method was similar to studies among welders in other low and medium income countries such as Nepal and Nigeria [11, 30, 44, 51-53]. Although it is the method of choice for most small scale welders, it has been associated with higher risks of exposure to welding hazards such as welding fumes and gases [13]. In the present study, the majority of welders reported to use mild steel in their work, others also

reported to use stainless steel which produces fumes that have been classified by the International Agency for Research on Cancer as possibly carcinogenic because of the presence of hexavalent chromium and nickel [13, 20].

In this study welders were observed working for long hours in open areas, exposed to direct heat from the sun, dust from the immediate environment and rain. A few of those who used their initiative to provide shade in their work stations made temporal structures that were not safe. In addition, most of the welders' tasks were done manually, involving heavy lifting of materials and products which put a lot of strain on the body of the workers. Also, welders in this study who operated on roadsides were at risk to injuries from the road traffic. Workers in the small scale enterprises are known to generally work in poor work conditions subjected to long working hours which exposes them to more hazards compared to their counterparts in larger industries [4, 54, 55]. A study in Tanzania on occupational exposures and health problems in small scale industry workers, who included welders, painters, woodworkers and metalworkers, also found that the welders had high levels of exposure to multiple health hazards [56]. Another study on occupational health in selected small scale and household industries, in Nepal, found that the occupational health and safety situation was unsatisfactory [57]. In the present study, it was observed that exposure to welding hazards was also extended to traders who operated in the same premises as welders in markets and on roadsides, including residents in close proximity to welding stands/workshops. This is a public health concern as persons who do not work, but just stay in the area or happens to be in the area even for a short period, may also be at risk of experiencing acute health effects related to exposure to welding hazards.

Welders' Awareness of Occupational Hazards

In the present study, the majority of welders were aware of at least one hazard related to their work. This compares well with studies on welders in Northern Nigeria and Eastern Nepal in

which the majority of welders (78% and 91% respectively) were aware of at least one or more workplace hazard [52, 53]. The present study found that among many other hazards related to their work, welders were least aware of noise and vibrations. Similarly, Eastern Nepal welders were less aware of vibrations [52]. However, in another study in Benin city of Nigeria, welders were least aware of hearing impairment as a health risk related to their work [44], similar to our present study. In the present study, most welders were aware of bright light and welding smoke, followed by sharp edges/metals. Similarly, excessive brightness was a welding hazard most welders were aware of in a study in Eastern Nepal, in contrast, more welders were aware of sharp metals than they were of welding fumes [52]. These variations regarding awareness of hazards could have been influenced by differences in the perception of consequences of exposure to these hazards.

Welding hazards such as the bright and blinding light of the welding arc, the choking smell of the welding smoke, the sharp metal edges as well as the hot and flying molten metal particles, present almost a direct threat to the welder's health and the consequences of exposure are nearly immediate. It was therefore not surprising that most welders in this study could easily identify them as health hazards. Furthermore, although annoying and uncomfortable, health consequences due to exposure to noise and vibrations become manifest after longer exposure periods. Thus these hazards may seem as a less obvious threat to those exposed, which might be the reason why welders in this and also in other studies had low awareness of these hazards.

Welders' Awareness and Use of Personal Protective Equipment

Of the different types of PPE recommended for welders, the welders in this study showed low level of awareness regarding hearing and respiratory PPE, but were more aware of safety shoes, work suits/coveralls, welding goggles and safety gloves. Therefore, it was not

surprising that most of the welders reported to use work suits/coveralls and safety boots in contrast to hearing and respiratory PPE. Similar findings were observed in a study from Eastern Nepal in which welders were least aware of hearing and respiratory PPE, and used this PPE less frequently than safety boots, gloves and welding goggles/eye shield which most welders were aware of and used when working [52]. Kumar et al, observed that none of the welders in their study in India were aware of any respiratory and hearing protective equipment and none of these welders used any respiratory PPE [42]. In a study among Northern Nigerian welders, eye goggles, hand gloves and safety boots, were the common types of PPE used [53]. It was found in the present study that welders used unconventional PPE (which offers no or minimal protection) such as sunglasses. This appears to be a common practice among welders in low-income countries as the majority of welders in Nepal were also found to use sunglasses which they considered protective.

Variations in the type of PPE commonly used among welders could be due to availability and access to the different types of PPE as observed in Nigeria [53]. The differences could also be due to variations in work cultures and safety practices among welders in these locations. In addition, the factor of comfort cannot be ruled out in the selection and use of PPE by the welders in these studies. For instance, welders in South Western Nigeria attributed their non-use of protective eye devices mostly to discomfort while a large proportion had no specific reason [51]. Overall, the present study found that a larger proportion of welders were aware of welding PPE compared to proportions of welders who reported to use the PPE. This difference between awareness and reported use of welding PPE observed in this study is an indication of the gap between the need and availability of the PPE, which creates a window of opportunity for preventive interventions in this working group.

Associations of Welders' Characteristics with Welding Hazards and Personal Protective Equipment (PPE) Awareness and Use of PPE

In this study, education was positively associated with awareness of welding hazards and PPE as well as with use of PPE. Those who had no formal education were less aware of welding hazards, PPE and also reported to use PPE less compared to those who were literate.

Similarly, a study on welders in Eastern Nepal found that level of education was significantly related to awareness of hazards and PPE as well as with use of the PPE. The authors attributed this association to the tendency of welders with higher education to read news, and other media sources [52]. In a study on Northern Nigerian welders, it was also observed that there was an association between educational attainment and awareness of hazards, which was attributed to better understanding of instructions by educated welders [53].

The Zambian curriculum for primary and secondary school education includes subjects such as metal work and other technical skills subjects, which are compulsory or optional depending on the choice of the management for different schools. Therefore, for the welders in our study, most of whom had received at least primary school education, it may be speculated that those who had received formal education could have come across hazard and PPE information included in these subjects. Furthermore, information in mass media is communicated in English which most illiterate people in Zambia are not able to understand. If any information regarding hazards or PPE is communicated, the welders with no formal education are at a disadvantage. In this study, use of PPE was also associated with the age of welders and their welding experience. Older participants reported to use PPE more compared to the younger welders. Budhathoki et al. attributed this type of association to the assumed higher risk taking behaviour among younger welders [52]. Similarly, the lack of experience of young welders compared to those older may lend support to the lower frequency of PPE use among the young and inexperienced welders.

Acute Health Effects

Burns and cuts on hands were among the most common acute health effects reported by the welders in this study. Welding is a hot process that involves production of hot and flying sparks, hot metal surfaces, molten metal droplets as well as thermal radiation from the welding arc that can burn exposed skin surfaces [15]. Exposed skin is at high risk to cuts and stabs from sharp metal edges. Also, flying metal particles can also be injected into the skin of the face, neck and hands [15]. Hence, it is not surprising that welders in this study, more than half of whom reported to have never used any hand PPE when working, had burns and cuts on their hands.

The majority of welders reported to have experienced red, itchy and running eyes as common acute health problems. Most welders also stated that acute health effects related to the eyes were the cause for staying away from work for at least one day or seeking medical attention. These symptoms belong to a widely known and documented problem of welders called ‘welders’ eye’, ‘arc eye’ or ‘arc flash’ [9, 28]. It is caused by exposure to ultraviolet (UV) radiation of the welding arc as well as welding smoke. Exposure to just a few seconds of intense UV light can cause arc eye, and the symptoms may not be felt until several hours after exposure [9, 28]. A study on welders in Northern Nigeria observed lower prevalence (17%) of arc eye related symptoms because most of the welders used welding goggles during their work [53]. However, this was not the case for welders in the present study as most reported to use sunglasses which are not the correct type of eyes PPE for welders as they offer very little, if any, protection to the welders. Also, foreign particles in the eye were reported as a common acute health problem for welders in the present study. A narrative analysis of welding related occupational eye injuries based on routinely collected workers’ compensation claims in the US revealed that the most common eye injuries were due to foreign particles in the eyes

followed by burns [58]. The international labour office also noted that foreign particles in the eye is a very common health effect in welding [15].

Symptoms of metal fume fever also accounted for a high number of health complaints among the welders in the present study. These symptoms included having a sweet metallic taste in the mouth, feeling of flu, body chills and fever, as well as general body weakness. A number of symptoms related to metal fume fever have been discussed in literature some of which include thirst, dry cough, a sweet or metallic taste in the mouth, chills, dyspnoea, malaise, muscle aches, headaches, nausea, and fever [19, 22]. Metal fume fever is reported to be among the most frequently observed acute illness of welders [19]. The condition often results from exposure to freshly formed fumes of zinc as welders join or cut through galvanised zinc coated materials and those containing other metals such as copper, cadmium manganese and iron [9, 19]. The illness is common in new workers or those returning to work from a period of rest from welding. Symptoms of metal fume fever are difficult to diagnose due to their similarities to mild influenza symptoms. The illness is self-limiting and usually resolves in 24 hours after onset and goes without residua [9]. However, some investigators have found a strong association between welding related MFF and welding related respiratory symptoms suggestive of occupational asthma [48].

It was found in this study that even those who reported to use respiratory and body PPE were at a high risk of experiencing acute health symptoms/effects. With regard to respiratory PPE, this was not surprising considering that the welders did not use the correct type of PPE for welding related hazards (i.e. fumes, gases and dust), also that this PPE was infrequently used during exposure. Furthermore, our observations indicate that the respiratory PPE used was in very bad state of repair and maintenance which presumably affected its effectiveness.

Similarly, those who used body protection did not wear it correctly as most welders had folded sleeves, open buttons or did not wear the full suit i.e. wore either the shirt only or the

pants only. Generally, it is likely that those who used the PPE were exposed to more hazards and hence felt the need to use the PPE. In addition, those who used the PPE might have had a false sense of protection against the hazards regardless of the fact that the PPE did not offer the protection intended.

Methodological Issues

The present study encountered a few limitations but it also had some strengths. The use of a cross sectional design limited the interpretation of results to only associations between study variables. No causal inferences can be made i.e. between exposure to hazards and health effects experienced by welders in the study. However, the information generated is important for descriptive purposes in informing plans for further action to improve work safety and protect the health of welders. As data was collected at only one point during the study, actual use of PPE as well as the frequency of use of the PPE could not be ascertained. For instance, some of the welders reported that they used some types of PPE always, although it is also possible that they did not, and there was no way of validating their reports. Effort was taken in making sure that the welders actually had access to the PPE they claimed to use by asking them to show the mentioned PPE. The use of observations in collecting data on occupational exposures was useful to the study as a more objective way of collecting data, in addition to self-reports by the welders.

Recall bias in the information provided by the welders is another limitation of the study as data was collected at one point. To ensure accuracy of the data collected the recall period was limited to the recent past two weeks for the health symptoms/effects experienced. With regard to internal validity of the study, the tools that were used were not validated and the questions used were not standardised. However, piloting was done to ensure that the tools were able to accurately collect information required for the achievement of the set objectives.

Six of those who were approached refused to participate in the study, our study would have benefited from their experiences. However, the sample sought for was met despite their refusal to participate. Regarding external validity, generalisation of the results is limited to welders in similar urban settings with similar demographic and regulatory provisions.

Conclusion

Welders in this study worked under poor and dangerous conditions that exposed them to several safety and health hazards. Although most welders were aware of occupational hazards and related PPE for their work, this awareness did not translate into use of PPE as the majority reported to have never used the recommended PPE while none of the welders reported to use all the required PPE at any given time. Welders reported to have experienced various acute health effects, the most frequent being eye, nasal, respiratory and metal fume fever related symptoms in addition to cuts and burns on the hands/arms. Their use of protective measures did not seem to offer the level of protection required against the hazards they are exposed to. Education was positively associated with awareness of both welding hazards and PPE as well as with the use of PPE. Also, the proportion of welders using PPE increased with an increase in age and welding experience.

Recommendations

Our findings call for great concern considering that occupational injuries and diseases have effects not only on work productivity but also on social and economic wellbeing of workers, their families and dependants [2, 59]. In addition, in light of the fact that the majority of the Zambian workforce work in small and informal enterprises, injuries and diseases of these workers puts a heavy burden on the already pressured health systems [3, 4, 60]. With such extensive effects, the contributions of welders and many workers in small enterprises to poverty reduction and sustainable economic development may not be fully harnessed, which further substantiates the need for promotion of good health and safe work for people in this

important working group. The following are the recommendations to the relevant stake holders:

Welders

- To the welders who already have the correct type of PPE, we recommend that they use this PPE at all times when they are exposed to welding hazards in order to avoid experiencing acute health effects.
- We recommend that welders create a welders' association or workers union for welders in Lusaka and Zambia in general that would provide a platform for communication of information between the welders and relevant stake holders such as the Labour Office, local authorities and funding agencies.
 - Better organisation of the small scale welders through the associations can enable welders increase their chances of accessing health education information regarding welding hazards and PPE as well as information on safe work practices.

Labour Office

- Develop strategies of training and delivering health education information to small and informal enterprises in order to improve awareness of welding hazards, PPE and health effects. The information should include messages on:
 - Identification and control of occupational hazards.
 - Selection, proper use and maintenance of personal protective equipment.
 - Health effects resulting from exposure to hazards related to their work.
- Develop policies and safe work code of practice tailored for the welders in Zambia that would provide guidelines for safety at work.

- To work with other stake holders such as the Zambia Bureau of Standards and Ministry of Commerce, Trade and Industry in ensuring that the correct type of welding PPE is made available on the Zambian market at costs that the welders can afford.

Ministry of Health

- Primary health care provision to include vigilant identification of occupational health injuries and diseases in order to provide the right treatment and counselling on prevention and control of welding related injuries and diseases for welders seeking medical attention.
- To provide information to the general public on welding hazards and their consequences on health in order to help them identify and avoid them whenever they are in close proximity to welding stands/workshops.

Lusaka City Council

- It is imperative that welders are provided with designated areas for their operations, especially those working in markets and roadsides, to isolate them from other traders and the general public. This would help prevent excess risk of exposure to welding related safety and health hazards.

Researchers

- Further research is recommended to investigate sustainable preventive strategies to control or reduce exposure to welding related safety and health hazards in order to preserve the health of welders in the small and informal enterprises in Zambia.

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Appendices

Appendix 1: Data Collection Tools

1A Structured Interview Guide

Occupational Hazards and Use of Personal Protective Equipment among Small Scale Welders in Lusaka, Zambia

ID Number _____ Market/stand number _____
Name of Interviewer _____ Date of Interview _____

SECTION A: DEMOGRAPHIC AND GENERAL INFORMATION

[Please tick (✓) and fill in where appropriate]

1. What is the sex of the welder?
i. Male () ii. Female ()
2. How old were you on your last birthday? Age (years) _____
3. What is your marital status?
i. Single () ii. Married () iii. Divorced () iv. Widowed ()
4. What is the highest level of education you attended?
i. None () ii. Primary () iii. Basic () iv. Secondary () v. Tertiary ()
5. How did you train to become a welder?
i. Apprenticeship training () ii. Technical training () iii. Other _____
6. Where any of the following covered in your training to become a welder?
i. How to conduct your work safely () ii. Health effects related to your work ()
iii. Use of protective clothing ()

SECTION B: EXPOSURE INFORMATION

[Please tick (✓) and fill in where appropriate]

1. For how long have you worked as a welder or in a welding workshop? No. of years _____
2. How long is your normal work day? Please specify: _____
<5 hours () 5-6 hours () 7-8 hours () 9-10 hours () 11-12 hours ()

3. Apart from welding, what other activities do you perform in your work?
 i. Grinding () ii. Painting () iii. Cutting () iv. Hammering () v. Cleaning ()
 vi. Other activities _____
4. What welding methods do you normally use?
 i. Manual Metal Arc (MMA) Welding () ii. Gas Welding ()
 ii. Other _____
5. How much time do you normally spend on welding? Please Specify: _____
 i. <1 hr. () ii. 1-3 hrs. () iii. 4-6 hrs. () vi. >7 hrs. ()
6. What products do you normally make or do you work on in your workshop/stand?

7. What materials do you normally use when welding?
 Please Specify _____

SECTION C: HAZARDS AND PPE KNOWLEDGE

[Ask the respondent the open ended questions below and tick the response options given or note down where necessary].

1. In your welding work, what do you know can cause injuries or harm to your health and/or the health of your fellow workers?

1) Bright light		6) Heat, fire or explosion	
2) Electricity		7) Sharp edges/metals	
3) welding fumes and gases		8) Flying sparks/particles	
4) Noise		9) Falling objects	
5) Vibrations		10) Uncomfortable work postures	

Other _____

2. What personal protective equipment do you know welders can use to protect themselves when welding?

Welding helmet		Work suit/coverall, Leather apron	
Hand shield		Ear muffs/ear plugs	
Goggles		Rubber soled, steel toe cap, safety shoes	
Respirators/face mask		Insulated gloves	

Other _____

SECTION D: USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE)

[Please tick (✓) and fill in where appropriate]

1. PPE for Eyes and Face

- i. Do you use anything to protect your eyes and face when welding?
Yes () No () [If yes, specify]
Safety goggles () Welding shield () Welding helmet () Other _____
- ii. How often do you use the mentioned protective equipment when welding?
All the time () Sometimes ()

2. PPE for Hearing

- i. Do you use anything to protect your ears/hearing when welding?
Yes () No () [If yes, specify]
Ear muffs () Ear plugs () Other _____
- ii. How often do you use the mentioned ear/hearing protection when welding?
All the time () Sometimes ()

3. PPE for Lung and Respiratory airways

- i. Do you use anything to cover your nose/mouth or to help you breathe when welding?
Yes () No () [If yes, specify]
Face masks () Respirators () Other _____
- ii. How often do you use the mentioned protection when welding?
All the time () Sometimes ()

4. PPE for Feet and Hands

- i. What type of shoes do you wear when welding?
Safety boots () Ordinary shoes () Other _____
- ii. How often do you use the mentioned protective shoes when welding?
All the time () sometimes ()
- iii. Do you use anything to protect your hands when welding?
Yes () No () [If yes, specify]
Insulated safety gloves () Other _____
- iv. How often do you use the mentioned gloves when welding?
All the time () Sometimes ()

5. PPE for the body trunk

- i. What do you use to cover your body when welding?
Work suit/coverall () Leather apron ()
Ordinary clothes () Other _____

- ii. How often do you use the mentioned protective clothing?
All the time () Sometimes ()

SECTION E: ACUTE HEALTH EFFECTS

[Please tick (✓) and fill in where appropriate]

Respiratory Symptoms

1. Have you ever experienced any of the following respiratory symptoms after welding work in the past two weeks?
 - i. Cough. Yes () No ()
 - ii. Shortness of breath. Yes () No ()
 - iii. Wheezing. Yes () No ()
2. Did you ever have to stay away from work because of any of these symptoms?
Yes () No ()
3. Did you ever have to go to a clinic/hospital because of these symptoms?
Yes () No ()

Nasal symptoms

1. Have you ever experienced any of the following nasal symptoms after welding work in the past two weeks?
 - i. Having a stuffy nose. Yes () No ()
 - ii. Having a running nose. Yes () No ()
 - iii. Sneezing after welding work. Yes () No ()
2. Did you ever have to stay away from work because of any of these symptoms?
Yes () No ()
3. Did you ever have to go to a clinic/hospital because of these symptoms? Yes () No ()

Eye symptoms

1. Have you ever experienced any of the following eye symptoms after welding work in the past two weeks?
 - i. Running eyes. Yes () No ()
 - ii. Irritated, red and itching eyes. Yes () No ()
 - iii. Flying particles entering your eyes Yes () No ()
2. Did you ever have to stay away from work because of any of these symptoms?
Yes () No ()
3. Did you ever have to go to a clinic/hospital because of these symptoms? Yes () No ()

Cuts

1. Have you ever experienced cuts on any of the following body parts during your work in the past two weeks?
 - i. Hands/arms. Yes () No ()
 - ii. Body trunk. Yes () No ()
 - iii. Feet Yes () No ()

2. Did you ever have to stay away from work because of any of these cuts? Yes () No ()
3. Did you ever have to go to a clinic/hospital because of these cuts? Yes () No ()

Burns

1. Have you ever experienced burns on any of the following body parts during your work in the past two weeks?
 - i. Hands and/or arms. Yes () No ()
 - ii. Body trunk. Yes () No ()
 - iii. Feet Yes () No ()
1. Did you ever have to stay away from work because of any of the burns? Yes () No ()
2. Did you ever have to go to a clinic/hospital because of the burns? Yes () No ()

Metal Fume fever

1. Have you ever experienced any of the following symptoms after welding work in the past two weeks?
 - i. Sweet metallic taste in the mouth. Yes () No ()
 - ii. Flu like symptoms. Yes () No ()
 - iii. Body chills and fever. Yes () No ()
 - iv. General body weakness. Yes () No ()
2. Did you ever have to stay away from work because of any of these symptoms? Yes () No ()
3. Did you ever have to go to a clinic/hospital because of these symptoms? Yes () No ()

Healthy Worker Effect Control

1. Do you know anyone working a welder who quit their job due to an injury from work? Yes () No ()
2. Do you know anyone working as a welder who died who died as a result of injury at work? Yes () No ()

Respiratory Effect Confounder Control

1. Have you ever smoked? Yes () No ()
2. Do you smoke at present? Yes () No ()
3. Have you given up smoking in the last month? Yes () No ()
4. Are you currently on medication for a respiratory illness? Yes () No ()

SECTION F: RECOMMENDATIONS FOR FUTURE ACTION

1. In your own opinion, what do you feel can be done to improve the welfare of people working as welders?

THE END!

THANK YOU FOR YOUR PARTICIPATION.

1B Checklist

Occupational Hazards and Use of Personal Protective Equipment among Small Scale Welders in Lusaka, Zambia

Name of workplace _____ Date of Inspection _____

Workplace address _____ Assessment by _____

1. Number of workers in the premise _____
2. Activities taking place in the in the area:
Welding () Sanding () Cutting () Hammering ()
Painting () Cleaning () Grinding ()
Other _____
3. Type of welding method used
i. Manual Metal Arc (MMA) Welding () ii. Gas welding ()
iii. Other () _____
4. Materials used in welding and welded on
Specify: _____
5. Work related exposures in the work environment
Airborne dust/fumes/gases () Flying particles () Extreme heat ()
Chemical splashes () Intense light () Sharp and rough edges ()
Falling objects () Slippery surfaces () Solvents ()
Noise () Vibrations () Other _____
6. **Note the PPE that is used.**
 - (a) **Face and Eye protection**
Goggles () Welding shield () Welding helmet () Other _____
Is eye protection provided with the correct filter lenses Yes () No ()
 - (b) **Hearing protection**
Ear muffs () Ear plugs () Other _____
 - (c) **Lung and respiratory airways protection**
Respirators () Face masks () Other _____
 - (d) **Body trunk (exposed skin) protection**
Fire/flame resistant apron () Fire/flame resistant work suit/coverall ()
Other _____

(e) Feet and Hands

Safety boots () Safety gloves ()

Other _____

Comment on provided PPE _____

Note if the following have been considered in the premise;

		Yes	No	Comment	
1.	Are work areas;	Well lit			
		Properly ventilated			
		Well arranged			
		Tidy			
2.	Are hazardous materials properly labelled?				
3.	Are safety data sheets available?				
4.	Is the work environment free from flammable material				
5.	Are electrodes removed from the holder when not in use?				
6.	If gas is used, are the cylinder properly secured?				
7.	Are shields/screens used to confine welding processes from other workers?				
8.	Is suitable certified fire extinguishing equipment available?				
9.	Are there safety signs or placards provided?				
10.	Is there any well-equipped first aid equipment available?				

Adapted from Cal/OSHA (2014) Hazards assessment checklist

Description of premises (indoor/outdoor environments)

Other observations and comments

End of Assessment

1C Informed Consent in English

Request for Participation in a Research Project

Study Title: Occupational Hazards and Use of Personal Protective Equipment among Small Scale Welders in Lusaka, Zambia

Background and Purpose

This is a request for you to participate in a research study that intends to gather information about work and health among small scale welders in Lusaka, Zambia. We are looking for people who are involved in welding and those who are working in welding shops; we hope you can provide us with information that will help in understanding the topic at hand.

Procedures

If you agree to be in this study, we will ask questions on your demographic characteristics, work activities, materials and equipment that you use, the personal protection equipment that you use as you work and some of the health effects that you have encountered as a result of your welding work. If you should come to any question you do not want to answer, just let us know and we will go on to the next question. Your honesty in providing the answers to the questions will be appreciated. The interview will take 10 minutes at the most.

Confidentiality

All the information that will be collected from you will be kept confidential and will not be shown to any other person. Identification will be by means of ID numbers that will be assigned to all participants. It will not be possible to identify you in the results of the study when these are published. All the questionnaires with their information will be destroyed at the end of this study in December 2015.

Voluntary Participation

Participation in the study is voluntary. There are no monetary benefits to you, we hope the information you will provide may be useful in improving your work. You can withdraw your consent to participate in the study at any time during the interview without stating any particular reason. If you later on wish to withdraw your consent or have questions concerning the study, you may contact the researcher on the address provided.

Jessy R. Z'gambo
University of Zambia
School of Medicine
Department of Public Health
P.O. Box 50110
Cell number: 0977 408689 E-mail: jessygambo88@yahoo.co.uk

Consent for participation in the study

I am willing to participate in the study.

(Signed by the project participant, date)

I confirm that I have given information about the study.

(Signed, role in the study, date)

1D Informed Consent in Bemba

Mwaipushiwa ukusendamo ulubali mwisambililo lyesu

Umutwe wesambililo: Amafya yasangwa mumilimo ya kochelela ifyela nefyakubomfya ukuichingilila pakubomba uyu mulimo mumatuka yanono mu Lusaka, Zambia

Ishintililo lye sambililo

Mwaipushiwa ukusendamo ulubali mwisambililo lyesu ilyo ililefwailikisha palwanchito nobumi bwa bantu abo ababomba imilimo yakoshelela ifyela muno Lusaka, Zambia. Tulefwaya abo ababomba imilimo yakochelela ifyela nabo abafwilisha mumatuka yanono ayakoshelela ukutwafwilisha ukwasuka amepusho ayenga twafwa ukwishishibisha pali iyi milimo.

Ifilinokuchitwa

Ngamwasumina ukusendamo ulubali mwisambililo ili, mwalaipushiwa amepusho ayapusana pusana panchito mubomba, ifyo mubonfya elyo nefyomuichingilila ukufuma kumasamso eyengesa pamulandu wamilimo mubomba. Ilyo tuleipusha amepusho, muli abakakuluka ukutwishibisha ngakuli ilyasuko tamulefwaya ukwasuka. Mube abakakuluka ukwasuka amepusho aya muchishinka nokufumaluka. Uku ukulanshanya kwalasenda insa ikumi limo nafisano (15 minutes)

Ifibi nefisuma ifingatumbuka mukuitumpa muli ili sambililo

Takwingaba ububi bwingasangwa muli ili sambililo, pantu isambililo lilefwayafye ukwishiba pamilimo yenu. Ifikatumbuka muli ubu ubwafwailisho fikafwilisha kamfulumende yesu ukulolekesha pabumi bwabantu bonse ababomba iyi imilimo yakochelela ifyela.

Inkama muli ili isambililo

Amasuko yonse ayalafuma kuli imwe yalasungwa munkama elyo tayakalagishiwe kumuntu ulionse. Tatwabomfye kaili tatwakabonfye ishina lyenu ukumishibilako muli ili isambililo pantu ninkama, lelo tukabonfya inambala twalamupela. Yonse ama pepala tulebomfya yakonaulwa pampela yesambililo ili.

Ukuipelesha

Ukuitumpa mwisambililo ili kushintilile mukuipelesha kwenu. Pakashita akalikonse kuti mwasala ukuleka ukwasuka amepusho. Ngamulefwaya ukwishibilapa nafimbi pali ili isambililo, kuti mwa ishibisha ba Jessy Zgambo pa keyala kapelwe pesamba.

Jessy R. Z'gambo
University of Zambia
School of Medicine
Department of Public Health
P.O. Box 50110
Cell number: 0977 408689
E-mail: jessygambo88@yahoo.co.uk

Ukuitumpa mwisambililo

Naipelesha ukusendamo ulubali muli ilisambililo.

(Siginecha yabo)

(Ubushiku)

Ndesuminikisha ukuti nimpela ukulondolola konse palwe sambililo ili.

(Siginecha yabo)

(Ubushiku)

(Ichiputulwa chabo muli ilisambililo)

Appendix 2: Results Tables

2A Summary of ANOVAs between awareness regarding welding hazards and welders' age, education and work experience

Welders' characteristics		Sum score	<i>df</i>	Mean square	F	P - value
Age (years)	Between groups	0.587	2	0.294	0.118	0.89
	Within groups	1062.201	426	2.493		
	Total	1062.788	428			
Level of education	Between groups	15.411	2	7.705	3.104	0.05
	Within groups	1060.133	427	2.483		
	Total	1075.544	429			
Welding experience (years)	Between groups	6.336	2	3.168	1.265	0.28
	Within groups	1069.209	427	2.504		
	Total	1075.544	429			

2B Summary of ANOVAs between awareness regarding use of PPE and welders' age, education and work experience

Welders' characteristics		Sum score	<i>df</i>	Mean square	F	P - value
Age (years)	Between groups	9.107	2	4.554	1.924	0.15
	Within groups	1008.445	426	2.367		
	Total	1017.552	428			
Level of education	Between groups	16.072	2	8.036	3.415	0.03
	Within groups	1004.728	427	2.353		
	Total	1020.800	429			
Welding experience (years)	Between groups	2.516	2	1.258	0.527	0.59
	Within groups	1018.284	427	2.385		
	Total	1020.800	429			

Appendix 3: Approval Letters

3A Approval Letter from Norwegian Regional Ethical Committee



Region:	Telephone:	Our date:	Reference:
REC Western Norway	+47 55978499	26.June 2014	2014/817/REK vest
		Your date:	
		25.June 2014	

To whom it may concern

Confirmation

We hereby confirm that the project "*Occupational Hazards and Use of Personal Protective Equipment among Small Scale Welders in Lusaka, Zambia*" with project manager Bente Elisabeth Moen, Professor, at the Department of Global Public Health and Primary Care, University of Bergen, is reviewed and approved by the Regional Committee for Medical and Health Research Ethics, Western Norway. Student Jessy Zgambo and student Chisala Meki are research project members.

Sincerely
Camilla Gjerstad
Advisor

This letter is approved for electronic dispatch without signature.

3B Approval Letter from Zambian Ethical Review Board



33 Joseph Mwilwa Road
Rhodes Park, Lusaka
Tel: +260 955 155 633
+260 955 155 634
Cell: +260 966 765 503
Email: eresconverge@yahoo.co.uk

I.R.B. No. 00005948
F.W.A. No. 00011697

11th September, 2014

Ref. No. 2014-July-017

The Principal Investigator
Ms. Jessie Z'gambo
C/O University Of Zambia, School Of Medicine
Department Of Public Health
P.O. Box 50110,
LUSAKA.

Dear Ms. Z'gambo,

RE: OCCUPATIONAL HAZARDS AND USE OF PERSONAL PROTECTIVE EQUIPMENT AMONG SMALL SCALE WELDERS IN LUSAKA, ZAMBIA.

Reference is made to your corrections dated 1st September, 2014. The IRB resolved to approve this study and your participation as principal investigator for a period of one year.

Review Type	Ordinary	Approval No. 2014-July-017
Approval and Expiry Date	Approval Date: 11 th September, 2014	Expiry Date: 10 th September, 2015
Protocol Version and Date	Version-Nil	10 th September, 2015
Information Sheet, Consent Forms and Dates	• English.	10 th September, 2015
Consent form ID and Date	Version-Nil	10 th September, 2015
Recruitment Materials	Nil	10 th September, 2015
Other Study Documents	Questionnaires, Checklist.	10 th September, 2015
Number of participants approved for study	424	10 th September, 2015

Where Research Ethics and Science Converge

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us.
- ERES Converge IRB does not "stamp" approval letters, consent forms or study documents unless requested for in writing. This is because the approval letter clearly indicates the documents approved by the IRB as well as other elements and conditions of approval.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of ERES Converge IRB, we would like to wish you all the success as you carry out your study.

Yours faithfully,
ERES CONVERGE IRB



Dr. E. Munalula-Nkandu
BSc (Hons), MSc, MA Bioethics, PgD R/Ethics, PhD
CHAIRPERSON

3C Approval Letter from Lusaka City Council



**LUSAKA CITY COUNCIL
MEMORANDUM**

TO : The Director of Housing and Social Services
FROM : The Director Human Resource & Administration
DATE : 25th July, 2014
REF : TCD/7/59/1/KNG/kng


SUBJECT: RESEARCH PROJECT - JESSY ZGAMBO

The above named individual is a student at the University of Bergen pursuing a Master in International Health that is run in collaboration with the Department of Public Health of the University of Zambia. She is currently carrying out a research on Occupation Health and Safety among the Small Scale Welders operating in the various Markets of Lusaka City.

She has since paid K73.21 as research fee on receipt number BV51613.

Kindly, assist her with the needed information so that she fulfills the necessary requirements towards the award of her degree.

Yours faithfully,


PP Namukolo M. Kalufyanya (Mrs)