BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Assessing the Awareness of Occupational Hazards and Application of Safety Measures among Welders at Marimba Industrial Cluster, Harare

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE BACHELOR OF SCIENCE (HONOURS) DEGREE IN SAFETY HEALTH AND ENVIRONMENTAL MANAGEMENT.

JUNE 2023

Declaration

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I, Alice Mutsawashe Kurotwi do hereby assert that this research project is my original extension with most of the material derived from other various sources as indicated in this dissertation.

Signature of the student: …… Date…13/07/2023……

To be completed by the supervisor

This dissertation is suitable for submission to the faculty and has been checked for conformity with the faculty guidelines.

Signature of the supervisor: …… Date: …….

Dedication

To my mother Nozipo Chimbumu whose moral support has remained inexorable, my husband Raymond Madanhi, my siblings Lennon and Amanda Chimbumu as well as my sons (Tamiranashe and Watidaishe) for their unwavering support.

Acknowledgements

I would like to thank the Almighty God for his continuous grace and favour he has shown me all throughout my university education and having seen me through the successful completion of my project.

My sincere gratitude goes to Dr. L. Mabhungu for the valuable guidance she has given me in the research of this project as well as the assistance and knowledge imparted in the write up of the same.

Many thanks also goes to the workmen at the Marimba Industrial Cluster whose cheerful engagement led to the successful completion of this study.

My gratitude also extends to my mother, husband, siblings and sons for their unwavering support and encouragement.

Abstract

Workplaces are essential environments for humans, and it is necessary to promote safe work practices. However, workplaces are laden with different hazards which workers are exposed to daily with varied consequences, such as ill-health, injuries or death. Welding is one occupation associated with hazards such as electric shock, fumes, and noise. As such, the study investigated the knowledge and adherence to safety and health procedures among small-scale welders in the Marimba Industrial Cluster. A cross-sectional research design with aid of questionnaires, observations and interviews with key informants was employed to gather data on hazards and personal protective equipment usage among small-scale welders. The study respondents were mostly males (82.9 %), in the 21-40 years' age class (58.5%). In addition, 68.3% attained ordinary level education, and over 50% of the respondents had 1-5 years working experience, attaining their welding education through apprenticeship (56.1%). The most known welding hazards were dust (100%), noise (78%), and fire and explosion (65.9%) whereas asphyxiation (34.1%) and vibration (39%) were the least known welding hazards. The most frequently used personal protective equipment were safety goggles (80.5%), safety boots (70.7%) and face shield (58.5%), and these were used for at least 4 to 7 days per week. The sociodemographic factors that significantly influenced awareness on welding hazards and related health among small-scale welders were age class (X^2 = 9.6014; p = 0.0451), educational level (X^2 = 10.3064; p = 0.0233), welding education (X^2 = 12.0531; p = 0.0331) and work experience (X^2 = 15.3667; p = 0.0175). Respondents that were aged above 21 years, and those who attained tertiary education had better awareness. Also, those with more than 5 years working experience, and apprenticeship trained were more knowledgeable on were welding hazards and related health. From the study findings it can be recommended that supervisors should ensure their welders abide to safety measures, whereas safety equipment and clothing should be readily available and accessible at all welding workstations. In addition, regulatory authorities should focus more on small-scale industries and enforce occupational health and safety regulations, whilst occupational health and safety training programs should be regularly implemented among welders to increase awareness and reduce occupational accidents and incidents.

Key words: awareness; hazard; personal protective equipment; and welding.

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List of Acronyms

APA	American Psychological Association
CBD	Central Business District
ILO	International Labour Organisation
LEDC	Less Economically Developed Countries
MIC	Marimba Industrial Cluster
MSD	Musculo-skeletal Disorders
NSSA	National Social Security Authority
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment/Clothing
SME	Small and Medium Enterprises
SPSS	Statistical Package for Social sciences
WHO	World Health Organisation

Chapter One: Introduction

1.1 Background to the study

The workplace is an essential environment for human life, with safe workplaces and safe working practices being key to increased productivity (ILO, 2021). Thus, it is necessary to promote safe work practices for industrial development especially among welders. However, no workplace is free from hazards (WHO, 2020), as many workers are exposed to different types of hazards, which include biological, chemical, mechanical, physical and psychosocial hazards (Awosan *et al.,* 2071; Nalugya *et al.,* 2022). As such, more than three billion employees are exposed to occupational hazards globally, with varied consequences, such as ill-health, injuries or death (Bhudathoki *et al.* (2014; ILO, 2021).

The major consequences of hazard exposure occur in the manufacturing sector with the situation more rampant in less economically developed countries. Approximately 12 million employees perish in LEDCs annually, and this is attributed to work-related injuries and diseases (WHO, 2020). One of the occupations associated with such incidents is welding. Welding practices consist of metal cutting and joining using flame and heat (Joseph *et al.,* 2017). Major hazards in welding industry are electric shock, ergonomics, fires, fumes, heat, intense light, and noise (ILO, 2021; Nalugya *et al.,* 2022). Lack of knowledge amongst welders increases the occupational risk as they are unaware of hazards, and the personal protective equipment (PPE) required (Wanjari and Wankhende, 2020).

In Zimbabwe, welding creates employment to a substantial number of Small and Medium Enterprises (SMEs), who usually operate informally at mechanic workshops, motor spare-parts markets, and along highways with about 3-5 welders per workshop (Mutembwa, 2022). High prevalence of work-related diseases and injuries among SMEs are due to limited occupational health and safety (OHS) services (Mutumbuki *et al.,* 2020). The OHS regulatory authorities focus more on large industries and seldom visit small-scale industries. Thus, no safety devices and mitigation measures are put in place by small-scale welders thereby increasing their vulnerability to occupational hazards (Itiakorit *et al.,* 2021). Also, most small-scale welders shun safety practices by putting money first at the expense of their health and safety (Mutembwa, 2022). In addition, Itiakorit *et al.* (2021) reported that the small-scale welders lack awareness on work hazards, health consequences, PPE usage, and control measures. As such, lack of awareness may have detrimental outcomes on these welders.

Despite employment in Zimbabwe being governed by occupational laws which regulate health and safety, and employee welfare, such as the Factories and Works Act of 1976, Labour Relations Act of 1996 and the NSSA Act, occupational accidents continue to rise (Mutembwa, 2022). According to Mutumbuki *et al.* (2020), the Zimbabwean industrial sector recorded nearly 200 accidents in the years 2020-2021. As such, there poses a need to investigate the OHS climate among small-scale welders considering that they are also involved in the fabrication of metal products. Thus, the present study seeks to evaluate awareness levels of small-scale welders on work-related hazards, control measures and associated diseases.

1.2 Problem statement

Work-related accidents have been increasing among small-scale welders, estimated at approximately 150 injuries annually though some are not reported. In addition, there is limited information on the level of awareness of these welders on OHS. Also, previous studies have focussed on large and heavy industries, as such, awareness on OHS and related effects among small-scale-welders is worth investigating.

1.3 Aim

To evaluate the awareness level and adherence to health and safety procedures among small-scale welders in the Marimba Industrial Cluster (MIC).

1.4 Objectives

1. To determine awareness on occupational hazards among small-scale welders in the MIC.
2. To determine awareness of and use of personal protective equipment among small-scale welders in the MIC.
3. To determine the sociodemographic factors associated with awareness on welding hazards and the likely health effects among small-scale welders in the MIC.

1.5 Research questions

1. What is the level of awareness on occupational health hazards among small-scale welders in the MIC?
2. What is the level of awareness of small-scale welders on welding health hazards and use of PPE in the MIC?
3. Which sociodemographic factors influence awareness on welding hazards and the likely effects among small-scale welders in the MIC?

1.6 Significance of the study

This research will provide baseline information and be used as a reference point and literature for related future studies. The study will also aid in enhancing awareness on occupational hazards and associated health effects among small-scale welders. The study findings and recommendations will serve as a guide for management and regulatory authorities in decision making and policy formulation towards OHS among small-scale welders.

Chapter Two: Literature Review

2.1 Status of global workplace safety and health

Safety in the workplace is imperative in promoting health (WHO, 2020), with ILO (2015) reporting a surge in workplace injuries in recent years. According to ILO (2021) approximately 150 million employees experience occupational accidents annually, with about 2.5 million fatalities due to unsafe or unhealthy workplace conditions. However, most organisations prefer a single occupational health and safety (OHS) performance assessment which only reduces workplace risks but does not eliminate them (Beyene *et al.*, 2019). As such, promoting awareness on occupational health and safety (OHS) practices requires a broader spectrum. ILO (2021) reported that globally, over 70% of the countries had OHS systems in place, whereas employees with OHS services was 18%.

Tadesse (2016) asserted that in developing countries, the management of occupational safety and health is still developing. This has resulted in lowering production as the work environment is not up to standard. In addition, most African countries resort to poor OHS practices (Itiakorit *et al.*, 2021) focussing more on pleasing their customers and undermining the safety and wellness of their employee. Moreover, the informal sector is highly vulnerable to workplace accidents and diseases due to absence of OHS systems, lack of PPE and non-compliance to OHS regulations. As reported by Wanjari and Wankhende (2020), lack of knowledge amongst welders increases the occupational risk as they are unaware of hazards and the PPE required.

2.2 Safety culture and safety climate among small-scale welders

According to ILO (2021), safety culture is defined as the attitudes, beliefs, perceptions and values that employees share in relation to safety, whose function is to promote a safe work environment. However, safety culture relies on job, psychological and situational factors (Maharja *et al.*, 2018). Moreover, according to Appiah (2021) culture is either static or dynamic thus it influences the workers' vulnerability to risk and health effects as a result of disparities in cultural and social norms. Also, the variations in employment structure and work circumstances may be influential. On the other hand, safety climate is defined as the shared perceptions by employees on rules, measures and habits concerning safety in the workplace (Payne *et al.*, 2018). In addition, safety climate is a predictor as well as an outcome of unsafe events, and the more unsafe events occur, the more vulnerable the employees become to hazards and risks (Appiah, 2021).

At present, approximately 3 million workers, operate as welders globally, with over 5 million executing welding tasks occasionally (ILO, 2021). In developing countries, safety and health-related problems are ever present and authorities have timeously tried to address these issues. However, the most neglected groups have been welders hence non-industrial welding is the major cause of occupational injuries (Beyene *et al.,*2019).

According to Appiah (2021) workplace safety culture is a product of employee attitude and behaviour. In his study in Ghana among small-scale mechanic shops, it was determined that the employees operated under poor working environment. In addition, organisational problems increased the risk and hazards. In a study by Wang *et al.* (2016) it was reported that small and medium enterprises lag behind large companies when it comes to OHS management and safety culture. This was mostly observed through poor adoption of safety protection, PPE and engineering controls. In addition, small firms seldom involve their employees in safety management or safety training, thus SMEs are more vulnerable to work-related injuries and ill-health. On the contrary, Maharja *et al.* (2018) concluded that shipyard welders in Indonesia had an excellent safety culture, which was achieved through practicing work safely, and reporting hazards and other safety issues.

2.3 Factors influencing safety culture and safety climate among small and medium enterprises

Safety culture and climate are a function of several factors which influence the success or failure of OHS management systems of many organisations. In a study by Unnikrishnan *et al.* (2015) it was concluded that safety culture and safety climate were affected by market lack of awareness, and finance, and resistance to change. However, competition with other companies was positively associated with better safety customs hence improved safety climate. Also, Woo (2015) revealed that lack of training, as well as soft policies on OHS regulations meant that SMEs hardly adhere to safe practices due to lax enforcement. On the other hand, Payne *et al.* (2018) asserted that safety culture and climate are influenced at three distinct levels, that is, individual, group and organisational level, which are controlled by personality and work attitude of the individual, group of organisation.

2.4 Hazards and potential health effects associated with welding

Welding is a profession which involves cutting and joining metal parts using an electric arc that produces flame, or other heat sources to melt, cut and fuse metal (Joseph *et al.,* 2017). Welding activities are high-risk activities which predispose welders to chemical, ergonomic

and physical hazards (Oluwole *et al.,* 2018; Itiakorit *et al.,* 2021). The most common hazards faced by welders include dust, electric shock, fires, fumes, heat, intense light, noise, and vibrations (Sabitu, 2009a; Saif Corporation, 2015; ILO, 2022; Nalugya *et al.,* 2022). In addition, welders perform repetitive work, lift heavy loads, and work at uncomfortable postures. Occupational risk among welders is increased by lack of awareness on associated hazards, not using PPE (Wanjari and Wankhende 2020) and absence of administrative controls (Atukunda *et al.,* 2019).

The common health effects arising from welding include photokeratitis (Sabitu *et al.,* 2009b; Atukunda *et al.,* 2019), metal fume fever, and affecting the functioning of lungs (Tadesse, 2016). Also, ILO (2022) and Nalugya *et al.* (2022) asserted that welding may lead to pneumoconiosis, asthma, due to inhaling dust and noxious gases, whereas Joseph *et al.* (2017) deduced that fertility abnormalities may arise from prolonged exposure to heat during welding. Johari *et al.* (2019) reported a high prevalence of musculo-skeletal disorders (MSD) among shipyard welders in Malaysia welders. In addition, most respondents had experienced neck, back, shoulder, elbow or wrist pain. Correspondingly, Zare *et al.* (2016) deduced that there is a high prevalence of MSDs among welders attributed to lack of regular work-rest cycle, and proper ergonomic conditions.

2.5 Methods and personal protective equipment employed to manage welding hazards

There are several of hazards emanating from welding, and these have cause significant adverse health impacts to the welders. As such, these require effective strategies to mitigate the potential risks they present. Some of the welding hazards, their likely consequences to the employees, and the proposed control strategies are shown in Table 2.1.

Table 2.1: Control strategies for some welding hazards (adopted from Saif Corporation, 2015)

Type of Hazard	Effects	Control mechanism
Electrical	Electric shocks, burns, injuries and death	Safe electrical work practices. Installation and repairs of electrical works should be done by qualified personnel Insulation

Ergonomics	Musculoskeletal injuries e.g. arms, back, elbows, neck and shoulder	Workstation and equipment design to be suitable a d comfortable
Fire	Burns and explosion	Removing combustible material around workstation. Fire extinguishers
Fumes and gases	Respiratory problems	Respirators, improved ventilation and short breaks
Heat	Heat rash, heat stress, hyperthermia and skin burns	Using cooling fans to increase air flow and ventilation Frequent breaks and rehydration
Noise	Noise induced hearing loss (NIHL)	Hearing protection, e.g. ear plugs and ear muffs. Regular audiometric tests
Radiation	Skin burns and eye problems	Coveralls, safety goggles, welding hoods
Sparks	Burns	Safety boots, glasses, gloves and coveralls

2.6 Awareness of occupational hazards and usage of PPE among welders

Several studies have been conducted on occupational health and safety (OHS) among welders the world over, with varying outcomes (Budhathoki *et al.,* 2014; Zare *et al.,* 2016; Nalugya *et al.,* 2022). In a study by Kumal *et al.* (2013), abrasions and lacerations were the major injuries whereas flash burns were the least. In addition, the 20 to 40 years' age group was the most welders. In another study by Johari *et al.* (2019) on the assessment of prevalence of work-related musculoskeletal disorders (MSDs) among welders in the shipyard industry in Malaysia. It was determined that most respondents complained of MSDs attributed to awkward postures, heavy lifting and repetitive works. In addition, the neck, upper back, and lower back, were most affected body parts.

In another study, by Chauhan *et al.* (2014) in India, it was concluded that most welders complained of skin irritations and eye symptoms attributed to irregular PPE usage. On the other hand, Nalugya *et al.* (2022) concluded that most welders wore PPE and had high level of knowledge on occupational hazards and mitigation measures. Similarly, Beyene *et al.* (2019)

in Ethiopia reported just 51% of respondents having knowledge of welding hazards, of which fire hazards were the most known. Also, a higher proportion of respondents used PPE due to its capacity to reduce welding hazards though some employed it by observing others. Likewise, Bhudathoki *et al.* (2014) in Nepal revealed that 90% of welders were cognisant of welding hazards, with excessive brightness, sharp metals and heat as the most notable hazards. The most used PPE was eye shields. In addition, educational level and work experience were positively correlated with knowledge on welding hazards. On the contrary, Ugwu *et al.* (2022) reported that neither age nor work experience influenced welders' conformity to PPE usage in Nigeria.

In Nigeria, Awosan *et al.* (2017), determined that 70% of respondents were knowledgeable of welding hazards, and the hazards they knew most were musculoskeletal problems, noxious gases and fumes. Moreover, the most common occupational accidents and injuries that were experienced by welders were burns, cut injuries, and eye injuries. Also, marital status and work experience were strongly associated with knowledge on welding hazards. In another study by Nalugya *et al.* (2022) in Uganda, it was determined that more than 95% acknowledged the use of PPE in reducing welding hazards, with the most used PPE being safety goggles. However, most respondents confirmed discomfort in the use of PPE, and none of the respondents were aware of regulations governing usage of PPE. Work experience and highest educational level attained positively influenced knowledge and attitudes on PPE usage (Nalugya *et al.*, 2022). In addition, most welders were not trained professionals, thus, Nalugya *et al.* (2022) also reported high prevalence of burns among welders attributed to not using protective gloves.

2.7 Summary

This chapter reviewed information on work-related hazards and health among welders. The potential hazards and health effects arising from welding were identified. In addition, the awareness of small-scale welders in some countries was reviewed. Therefore, the following chapter dwells on methods employed to obtain the set objectives.

Chapter Three: Research Methodology

3.1 Description of Study Area

The study was conducted in welding stalls of Marimba Industrial Cluster (17°52’17.22” S and 30°56’17.45” E) which is located approximately 5km from Harare central business district. The location of the study area is shown in Figure 3.1. The area is dominated by small and medium businesses involved in the manufacturing sector. Some of the products generated in the area include garden tools, steel chairs and tables, sliding gates, window and door frames, as well as poultry and rabbit cages.

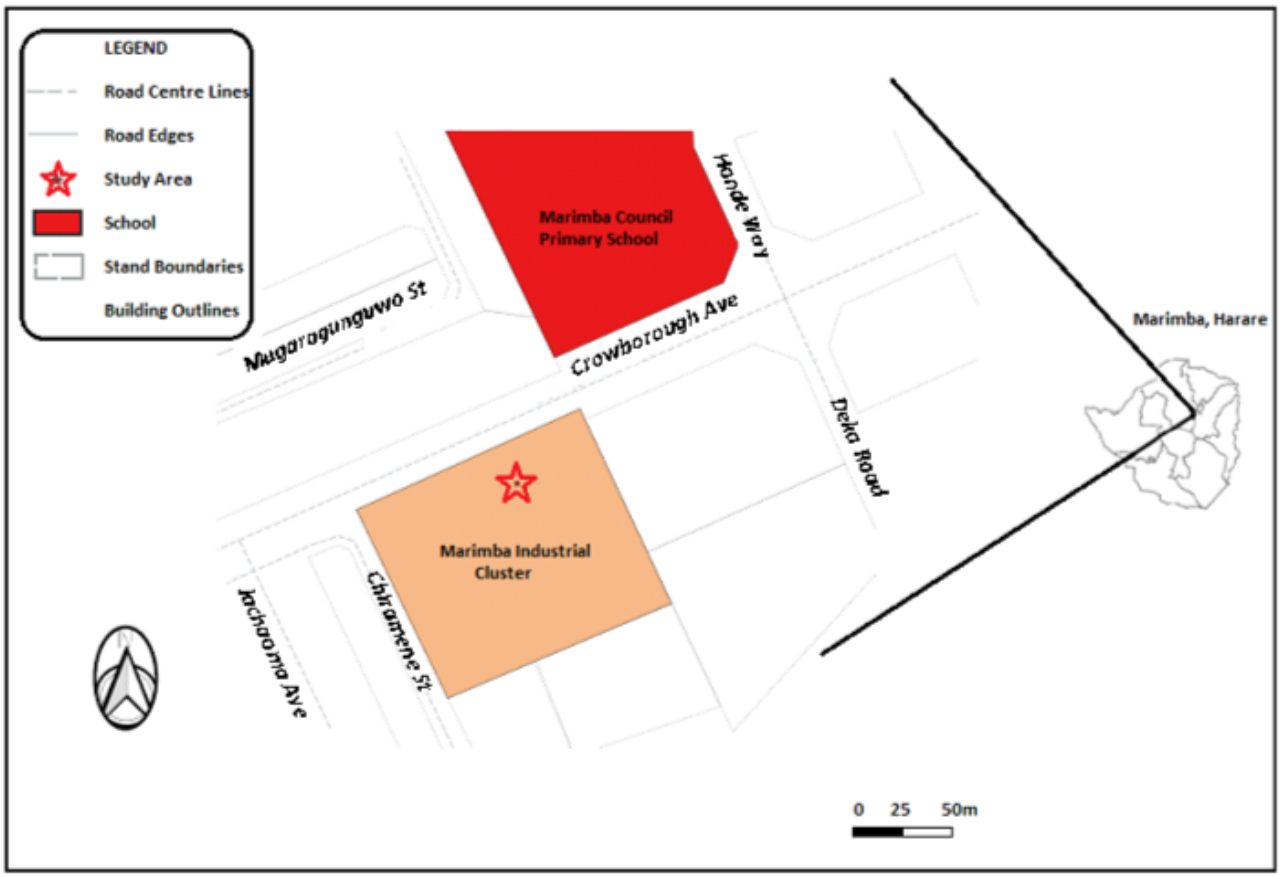

Figure 3.1: Location of study area

3.2 Research Design

Saunders *et al.* (2019) defines research design as the general approach selected to combine the study elements in a comprehensive and reasonable way, thus efficiently tackling the study problem. The study employed a cross-sectional research design. This approach was chosen as it captures information associated with the presence of physical hazards and their effects on health among welders at a particular time. Thus, the study used questionnaires and interviews to determine awareness on hazards and their likely effects, and personal protective equipment (PPE) usage among small-scale welders. In addition, observations will be done to identify PPE usage.

3.3 Study Population and Sample Size

The study was conducted among small-scale welding workers in the Marimba Industrial Cluster (MIC). Participants were all workers engaged in welding activities. The MIC has an estimated population of 45 welders. The size of the sample for questionnaire dissemination was calculated using Cochran's sample size formula (Appendix 1) as described by Israel (2009). Thus, the sample size was 41 welders chosen randomly for questionnaire dissemination. In addition, interviews were conducted with five randomly selected key informants.

3.4 Data Collection Tools

The data collection tools included questionnaires, observations and interviews with key informants as described below.

3.4.1 Questionnaire

Leedy and Omrod (2021) defines a questionnaire as a tool for observing data remotely by the researcher. Questionnaires require a written response to the probing questions, and are mainly used because they are efficient and save time. The questionnaires were administered to 41 respondents, comprising of welders and general assistants to determine the awareness of welders on work-related hazards and associated health effects, as well as PPE usage.

A questionnaire (Appendix I) with close-ended and open-ended questions was used to gather data which was both qualitative and quantitative. The questionnaire was separated into four sections, namely A) socio-demographic information; B) awareness of occupational hazards;

C) awareness of safety mitigations; and D) availability and utilisation of safety mitigations. As opined by Cresswell (2014) questionnaires are an effective technique of data collection due to their flexibility. In addition, Gilham (2008) asserted that questionnaires offer respondent anonymity, and use time efficiently.

3.4.2 Observations

Observations were done to augment the questionnaire, and this involved walking around the MIC, observing the day-to-day welding tasks. This was done with the aid of a checklist (Appendix 2) observing activities such as the use of PPE, ergonomics, house-keeping, and possible hazards.

3.4.3 Key Informant Interview

In-depth interviews (Appendix 3) with key informants were conducted. These included selected welding supervisors and workshop managers in the MIC. Prior to interviews, consent for interviewing was sought via telephone, whereas the interviews were done face-to-face. The interviews aimed at determining information on welding hazards and the associated health effects of welding. As opined by Cohen and Morrison (2011), the advantage of interviews is that they acquire in-depth information.

3.5 Ethical Considerations

Ethical issues in this study were observed according to the American Psychological Association (APA), 2017, key code of ethics. The research ethics included seeking consent before interviews, confidentiality and anonymity. Bindura University granted authority to undertake the study, and the participants partook voluntarily in the study and were entitled to withdraw or stop the interview as they required (APA, 2017).

3.6 Reliability and Validity

To reduce bias and guarantee reliability, a respondent validation exercise was done through returning questionnaires to respondents so that they validate or refute interpretation of the data by the researcher as described by Burnard *et al.* (2008). According to Creswell and Creswell, (2017) the exercise is done a few days after data collection to reduce the respondents' perceptions as a result of potential changes in their situation or health. In addition, University Lecturers independently reviewed the questionnaires transcripts and analysed data to ensure

reliability thereby eliminating potential bias from a lone researcher (Cohen and Morrison, 2011).

As described by Saunders *et al.* (2019) validity is the scale to which an instrument evaluates what it is claimed to measure, and based on the test results, inferences can be made appropriately. The questionnaires were reviewed by University Lectures whereas a pilot-study of the questionnaire was done on ten welders who did not participate in the study, to ascertain the appropriateness of the questions, as well as rephrase and adjust some questions to remain appropriate with the study. This is in accordance with Creswell and Creswell (2017), who highlighted that pilot tests are studies done to ensure the relevance and suitability of the questionnaire as well its precision.

3.7 Statistical Analysis

Data from the questionnaire was coded, and entered into Microsoft Excel and then transferred into version 22.0 of the Statistical Package for Social Sciences (SPSS). In SPSS, descriptive statistics were used to analyse the data. The correlation involving socio-demographic attributes of respondents with awareness on welding hazards and associated health effects were analysed using a chi-square test. The confidence level was set at 95%, whereas $p < 0.05$ was the significance level.

Chapter Four: Results

4.1 Socio-demographic attributes of respondents

Most respondents were aged 21-40 years (58.5%), and the majority (82.9 %) were males. In addition, over 56% of the respondents were married, with 68.3% attaining ordinary level education. Also, over half of the respondents had 1-5 years working experience, had attained their welding education through apprenticeship (56.1%), and were head welders (53.7%). The sociodemographic characteristics of the respondents in the Marimba Industrial Cluster (MIC) are shown in Table 4.1.

Table 4.1: Socio-demographic attributes of respondents in the Marimba Industrial Cluster

Variable	Category	Frequency	Percentage
1. Age class	< 20 years	10	24.4
	21 – 40 years	24	58.5
	41 – 60 years	7	17.1
2. Gender	Male	34	82.9
	Female	7	17.1
3. Marital status	Married	23	56.1
	Divorced	5	12.2
	Single	10	24.4
	Widowed	3	7.3
4. Educational level	Ordinary level	28	68.3
	Advanced level	8	19.5
	Tertiary level	5	12.2
5. Work experience	< 1 year	7	17.1
	1 – 5 years	24	58.5
	6 – 10 years	7	17.1
	> 10 years	3	7.3
6. Welding education	Self-taught	11	26.8
	High school	4	9.8
	Apprenticeship	23	56.1
	On-job	3	7.3
7. Work position	Head welder	22	53.7
	Assistant welder	10	24.4
	General hand	9	22.0

4.2 Awareness of occupational health hazards by small-scale welders in the Marimba Industrial Cluster

The most known welding hazards were dust (100%), noise (78%), and fire and explosion (65.9%). On the other hand, asphyxiation (34.1%) and vibration (39%) were the least known welding hazards (Table 4.2). In addition, those who acknowledged being very familiar with welding hazards ranged from 4.8% to 70.7%, whereas those who were very unfamiliar ranged from 2.4 – 4.8%. Also, through observations of selected welding stalls, it was determined that safety toolbox talks were not conducted, no hazard warning signs or hazard mitigation charts were erected, thus hazard communication between co-workers was non-existent. However, most work stations had good house-keeping practices.

Table 4.2: The occupational hazards known by sampled welders in the MIC

Welding Hazard	Level of awareness					Total freq. (%)
	Very familiar freq. (%)	Familiar freq. (%)	Not Sure freq. (%)	Not familiar freq. (%)	Very unfamiliar freq. (%)	
1. Asphyxiation	2 (4.8)	3 (7.3)	4 (9.7)	3 (9.7)	2 (4.8)	14 (34.1)
2. Fire or explosion	22 (53.7)	5 (12.2)	-	-	-	27 (65.9)
3. Toxins and toxicity	12 (29.3)	4 (9.7)	2 (4.8)	1 (2.4)	-	19 (46.3)
4. Gases and fumes	15 (36.6)	5 (12.3)	2 (4.8)	1 (2.4)	1 (2.4)	24 (58.5)
5. Radiation and heat	14 (34.1)	3 (7.3)	2 (4.8)	-	-	19 (46.3)
6. Dust	29 (70.7)	12 (29.3)	-	-	-	41 (100)
7. Noise	26 (63.4)	6 (14.6)	-	-	-	32 (78.0)
8. Vibration	9 (21.9)	2 (4.8)	2 (4.8)	2 (4.8)	1 (2.4)	16 (39.0)
9. Intense light	13 (31.7)	6 (14.6)	3 (7.3)	-	-	22 (53.7)
10. Electric shock	14 (34.1)	5 (12.2)	-	-	-	19 (46.3)

NB: very familiar=75-100%; familiar=50-75%; not sure=0%; not familiar=25-50%; very unfamiliar=0-25%

4.3 Awareness of and use of personal protective equipment among small-scale welders in the MIC

Most respondents acknowledged safety boots (85.4%) as part of PPE and were aware of what they protected. Other types of PPE that were considerably known were coveralls (78%), as well as both ear plugs and gloves attaining values of 75.6% respectively. However, air filters (39%) were the most PPE used without knowledge of what they protected (Table 4.3). Also, observations revealed that some respondents did not wear their PPE properly, whereas others did not wear the required PPE at all, especially gloves, respirators and safety goggles. This corresponds with information gathered during interviews with key informants as mentioned below:

Interviewee 1 stressed that *"welders choose not to use PPE such as gloves and respirators as they consider them to be uncomfortable".*

Interviewee 3 stated that *"the welders are aware of the consequences of not using PPE, thus those who do not wear the PPE, do it out of negligence".*

Table 4.3: Awareness on usage of personal protective equipment by small-scale welders in the Marimba Industrial Cluster

Type of PPE	Level of awareness. Frequency (%)		
	Know what it is and what it protects	Know how to use it	Just use it without knowing what it protects
1. Safety goggles	23 (56.1)	17 (41.5)	1 (2.4)
2. Coveralls	32 (78.0)	9 (22.0)	0 (0.0)
3. Safety boots	35 (85.4)	6 (14.6)	0 (0.0)
4. Gloves	31 (75.6)	10 (24.4)	0 (0.0)
5. Respirator	29 (70.7)	12 (29.3)	0 (0.0)
6. Hard hat	26 (63.4)	8 (19.5)	7 (17.1)
7. Ear plugs	31 (75.6)	10 (24.4)	0 (0.0)
8. Face shield	27 (65.9)	8 (19.5)	6 (14.6)
9. Air filter	17 (41.5)	8 (19.5)	16 (39.0)
Average Total	27.8 (68.0)	9.7 (23.8)	3.3 (8.1)

The most frequently used PPE were safety goggles (80.5%), safety boots (70.7%) and face shield (58.5%), and these were used for at least 4 to 7 days per week. The PPE that were never used by the respondents were air filters (56.1%) and hard hats (39%). The type of PPE and frequency of its usage by small-scale welders in the MIC is shown in Table 4.4.

Table 4.4: Frequency of PPE usage by small-scale welders in the MIC

Type of PPE	Frequency of usage in days per week. Frequency (%)		
	Frequently (4 – 7 days)	Rarely (1 – 3 days)	Never (0 days)
1. Safety goggles	33 (80.5)	8 (19.5)	0 (0.0)
2. Coveralls	22 (53.7)	19 (46.3)	0 (0.0)
3. Safety boots	29 (70.7)	12 (29.3)	0 (0.0)
4. Gloves	21 (51.2)	15 (36.6)	5 (12.2)
5. Respirator	15 (36.6)	12 (29.3)	14 (34.1)
6. Hard hat	11 (26.8)	14 (34.1)	16 (39.0)
7. Ear plugs	14 (34.1)	17 (41.5)	10 (24.4)
8. Face shield	24 (58.5)	17 (41.5)	0 (0.0)
9. Air filter	0 (0.0)	18 (43.9)	23 (56.1)

4.4 Socio-demographic factors influencing awareness on hazards and related health among small-scale welders in the Marimba Industrial Cluster

Age class (X^2 = 9.6014; p = 0.0451), the level of education attained (X^2 = 10.3064; p = 0.0233), and working experience (X^2 = 15.3667; p = 0.0175) were positively correlated with awareness on occupational hazards and associated health effects among the small-scale welders. On the other hand, welding education (X^2 = 12.0531; p = 0.0331) was negatively associated with awareness on occupational hazards and health. However, gender, marital status and work position had no influence on awareness of welding hazards. Table 4.5 shows the sociodemographic factors associated with awareness on welding hazards and related health among small-scale welders in the MIC.

Table 4.5: The sociodemographic characteristics of the respondents in MIC

Variable	Category	Pearson's X^2 – Test	
		X^2 – Test value	*p – Value*
1. Age class	< 20 years 21 – 40 years 41 – 60 years	9.6014	0.0451*****
2. Gender	Male Female	3.8182	0.8237
3. Marital status	Married Divorced Single Widowed	14.3708	1.0279
4. Educational level	Ordinary level Advanced level Tertiary level	10.3064	0.0233*****
5. Welding education	Self-taught High school Apprenticeship On-job	12.0531	0.0331*****
6. Work experience	< 1 year 1 – 5 years 6 – 10 years > 10 years	15.3667	0.0175*****
7. Work position	Head welder Assistant welder General hand	5.5972	0.4441

***** Denotes significantly different

Chapter Five: Discussion

5.1 Awareness of occupational health hazards by small-scale welders in the Marimba Industrial Cluster

All respondents in this study knew at least one hazard associated with welding, with the most known welding hazards being dust, noise, and fire and explosion (Table 4.2). This could be attributed to the fact that most welders worked outdoors, where dust is frequent, also noise was well known due to the large sound made when using grinders to cut metal. This concurs with Tagurum *et al.* (2018) who reported 99% of respondents knowledgeable with at least one work-related hazard connected to welding. The work-related hazards common in their study were noise (93.2%), fumes (91.2%) and heat stress (45.8%). Similarly, Awosan *et al.* (2017) reported fumes and dust as most common hazards whereas Wanjari and Wankhende deduced fumes, electrical shock and noise as the most known welding hazards. On the other hand, the least known hazards associated with welding were asphyxiation and vibration. This again could have been a result of working in well ventilated areas thus suffocation is uncommon. In addition, there was a high number of respondents who were very familiar with welding hazards in contrast to those who were very unfamiliar.

5.2 Awareness of and use of personal protective equipment among small-scale welders in the MIC

In this study, 68% of the respondents were aware of PPE and used it knowingly. However, this was lower than the values of 90% and 86.5% reported by Tagurum *et al.* (2018) and Beyene *et al.* (2019) respectively. Safety goggles, safety boots, and coveralls were the most used PPE (Table 4.3) tallying with Beyene *et al.* (2019) who reported the most frequently used PPE being safety goggles (80.8%), and face shield (75.8%). Similarly, Tagurum *et al.* (2018) concluded that the most used PPE by welders were safety goggles (98%), gloves (65.4%) and safety boots (58%). Also, Nalugya *et al.* (2020) reported 86.5% of the respondents acknowledging PPE usage. In their study, the most used PPE were safety goggles, whereas earmuffs were the least known. The reason safety goggles were the most known type of PPE could mainly have been due to the high possibility of eye injuries attributed to welding. As such, welders tend to protect

eyes more compared to other body parts. However, some respondents acknowledged using PPE merely due to observing and coping others.

The frequency of PPE usage was high (4 to 7 days per week) corresponding with Nalugya *et al.* (2020) who determined that nearly 60% of respondents always used PPE. In the present study, the PPE that were never used by the respondents were air filters and hard hats due to unavailability. As mentioned by Awosan *et al.* (2017) some welders did not use PPE because they did not have it, for example, boots, ear plugs, face masks and hard hats. On the other hand, Budhathoki *et al.* (2014) and Nalugya *et al.* (2020) reported some welders using unconventional PPE not recommended by safety regulators as they were cheap and comfortable. However, such unconventional PPE increased accident and occupational illness vulnerability. In addition, some did not use the PPE because they had no awareness of its importance and usage, whereas some respondents felt uncomfortable when wearing the PPE, for example, gloves and respirators hence they removed them. This tallies with Awosan *et al.* (2018) who reported that PPE such as gloves causes discomfort among welders hence they are seldom used. Such malpractices increase the likelihood of burns, cut, and inhaling of dust and fumes resulting in serious adverse health conditions.

Wanjari and Wankhende (2020) reported a lack of hazard and safety awareness among welders as well as lack of PPE usage attributed to no safety training. This tallies with Beyene *et al.* (2019) who reported that welders did not use PPE as it decreased work performance, and made them uncomfortable. In addition, lack of safety supervision and OHS regulation enforcement in small-scale welding contributes to the high numbers not using PPE (Nalugya *et al.*, 2020). In most scenarios, welders consider money first, at the expense of their own safety, hence they do not practice safe occupational procedures in a bid to hurriedly complete work-tasks and get paid. As such some welders consider safety training and buying PPE a waste of time and resources (Nalugya *et al.*, 2020).

5.3 Socio-demographic factors influencing awareness on hazards and related health among small-scale welders in the Marimba Industrial Cluster

This study determined that age class, level of educational attained, welding education and work experience significantly shaped awareness on occupational hazards among the small-scale

welders (Table 4.4). With age, one gains experience on how to identify and mitigate hazards as such those aged less than 20 years were less aware of welding hazards than those aged above 20 years. In addition, those who attained higher level education were more knowledgeable than those with lower educational levels considering that literacy promotes a better understanding of safety measures. As asserted by Tagurum *et al.* (2018) and Beyene *et al.* (2019) long working experience among welders increases their knowledge on welding hazards and safety. In addition, Awosan *et al.* (2017) determined that age, marital status and length of work practice significantly influenced knowledge on welding hazards, whereas Budhathoki *et al.* (2014) reported that educational level significantly influenced welding hazard awareness, and PPE usage. On the contrary, Ugwu *et al.,* (2022) reported that age and work experience was not positively associated with compliance on usage of safety goggles among welders.

Alternatively, Nalugya *et al.* (2020) deduced that mode of training was highly associated with welding hazard awareness and PPE usage, with those formally trained being more knowledgeable than those who were apprenticeship trained. Likewise, Tagurum *et al.,* (20218) confirmed that those with apprenticeship training were less knowledgeable than those with institutional training. This is because on-job trained dwells more on skill training and undervalues the importance of safety and health.

Chapter Six: Conclusion and Recommendations

6.1 Conclusion

From the study findings, it was shown that most respondents were aware of the welding hazards, with the commonly known hazards being dust, noise and fire. The majority of respondents wore personal protective equipment (PPE) and the frequently used PPE were safety goggles, safety boots and face shields. Those who did not use PPE attributed it to unavailability, caused discomfort or decreased work efficiency. The sociodemographic characteristics that influenced awareness on welding hazards and related health among small-scale welders included age class, educational level attained, welding education and work experience.

6.2 Recommendations

Considering the research outcomes, it can be suggested that:

1. Workplace supervisors should ensure their welders abide to safety measures, through reporting potential hazards and consistent use of PPE.
2. Safety equipment and clothing should be readily available and accessible at all welding workstations.
3. Regulatory authorities should focus more on small-scale industries and enforce OHS regulations.
4. OHS training programs should be regularly implemented among welders to increase awareness and reduce occupational accidents and incidents.
5. Future studies to focus on ergonomics survey amongst welders.

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Appendices

Appendix 1: Determination of Sample Size

$$n = \frac{N}{1 + N(e)^2} \quad \text{……..…….. Eqtn. 1}$$

where, n = sample size; N = population size; e = level of precision.

$$\frac{45}{1 + 45\,(0.05)^2} \rightarrow \frac{45}{1 + 45(0.0025)} \rightarrow \frac{45}{1 + 0.1125} \rightarrow \frac{45}{1.1125} \approx 40.4494$$

$$\therefore n = 41$$

Thus a total of 41 welders were randomly selected for questionnaire dissemination.

For interviews, a total of five (5) key informants were randomly selected, from the Marimba Industrial Cluster and these included supervisors and workshop managers

Appendix 2: Questionnaire

My name is Alice Kurotwi. I am a Student at Bindura University (Registration No. B192673B) in the department of Environmental Science and I am undertaking a research on *"Assessing the Awareness of Occupational Hazards and Application of Safety Measures Among Welders at Marimba Industrial Cluster"*. I would like you to assist me with information on this matter, provided you are willing to take part in the study. Participation in this study is entirely voluntary and any information provided will be treated as classified and confidential. The study findings will be used to make recommendations on the prevention and control of occupational hazards in the small-scale welding industry in Zimbabwe

Section A: Demographical Information ***(****Please tick in the appropriate box provided).*

1. Age group: < 20years ☐ 20-40 years ☐ 41-60 years ☐ ≥ 60years ☐
2. Gender: Male ☐ Female ☐
3. Marital status: married ☐ single ☐ widowed ☐ divorced ☐
4. Education: none ☐ primary ☐ secondary ☐ tertiary ☐
5. Work experience: < 1 year ☐ 1-5 years ☐ 5-10 years ☐ >10 years ☐
6. Welding education: self-taught ☐ high school ☐ apprenticeship ☐ on-job ☐
7. Position: head welder ☐ assistant welder ☐ general hand ☐

Section B: Awareness of Occupational Hazards

Highlight your knowledge of the listed hazard. (*please tick appropriate answer)*

Welding Hazard awareness amongst Welders					
Type of Welding Hazard	Very familiar	Familiar	Not Sure	Unfamiliar	Very Unfamiliar
Asphyxiation (lack of oxygen)					
Fire or explosion					
Toxicity					
Toxic gases					
Metal fumes					
Radiation/Heat					
Particulate Matters/Dust					
Noise					
Sensitizer (Sensitising Chemicals)					
Respiratory Irritants					
Systemic Toxins					
Neurotoxins and reproductive toxins					
Carcinogen					
Mixture effects					
Vibration					
Poor lighting					
Electrocution and Electric Shocks					

Section C: Awareness of safety mitigations *(Please tick in the appropriate boxes)*

Awareness of safety measures among the welders studied			
Safety measures	Know what it is and what it protects against?	Know how to use it	Just use it without knowledge of why?
Eye Goggles			
Coverall			
Safety shoe			
Glove			
Respirator			
Helmet			
Ear plug (Ears-Muffs)			
Boots			
Face Shield/mask			
Preventive and therapeutic medicines			
Air filter			
Storage Area (Availability)			
Others			

Section D: Availability and Utilisation of Safety Mitigations

Indicate the availability of mitigation measures and frequency of utilisation where mitigations are available.

Use of Mitigation Measures				
Type of Mitigation/Safety measure	Availability	Utilization (when available)		
		4–7 days	1–3 days	Never
Eye Goggles				
Coverall				
Safety shoe				
Glove				
Respirator				
Helmet				
Ear plug				
Safety boots				
Face Shield/mask				
Preventive and therapeutic medicines				
Air filter				
Storage Area				
Other				

END OF QUESTIONNAIRE ……. THANK YOU

Appendix 3: Observation Checklist

Observations	Status	Additional Notes
Number of employees at work station		
Safety talks conducted		
Hazard warning signs erected.		
PPC/E stored correctly		
Required PPC worn effectively		
Hazard communication between co-workers		
Behaviour between employee and client/customer		
Sharing work equipment/tools		
Housekeeping within welding shops		
Manner of mitigation and frequency of use		
Literature on hazards and mitigations present/absent in weld shops		
Hazards charts vs mitigation charts		
Accident/Incident statistics records		

Appendix 4: Key-informant Interview Guide

My name is Alice Kurotwi. I am a Student at Bindura University in the department of Environmental Science and I am undertaking a research on *"Assessing the Awareness of Occupational Hazards and Application of Safety Measures Among Welders at Marimba Industrial Cluster"*. I would like you to assist me with information on this matter, provided you are willing to take part in the study. Participation in this study is entirely voluntary and any information provided will be treated as classified and confidential. The study findings will be used to make recommendations on the prevention and control of Occupational Hazards in the Small-Scale Welding industry in Zimbabwe.

Interview guide No: ..... **Date: .....**

Section A: Awareness of Occupational hazards.

1) Do you consider welding a hazardous occupation? yes ☐ no ☐

2) What are the most prevalent hazards within the welding work environment?

……..……

……..…..…….…..…

……..……

……..……

3) Please list at least ten (10) hazards you are aware of, within your occupation?

……

……

……

……

……

……

……

4) Within the welding shop, are there any hazards with long term and irreversible effects to health? yes ☐ no ☐

5) If yes in (4) above, highlight the nature of those effects?

……

……

……

……

6) Ensuring the donning and utilisation of PPE/C is the responsibility of? manager ☐ supervisor ☐ welder ☐ everyone ☐

7) Do you consider long working hours, poor postures and repetitive motions hazards? *Please explain.* ……..

……..

……..

……..

8) Is there reporting of accidents and dangerous occurrences to the NSSA and their investigation? yes ☐ no ☐

9) Is there the provision and dissemination of safety and health information, instruction, training and supervision within the weld shop? *Also highlight frequency and by whom.* yes ☐ no ☐ ……
……..
……..

10) Are Reassessments and Hazard Analysis conducted? yes ☐ no ☐

Section B: Awareness of awareness of safety measures

11) For the hazards highlighted in Section A list the full safety mitigations required to reduce or eliminate the hazards?
……
……..
……..
……..
……..
……..

12) Is it necessary to always make use of PPC/E always? yes ☐ no ☐

13) Are there any circumstances that warrant working without full PPC/E? yes ☐ no ☐

14) If yes in (13) above. *Please highlight those situations.* ……

15) What are the main reasons for non-use of safety measures? ……...
……..
…….

16) Are all safety measures in good working order? yes ☐ no ☐

17) Do welders know how to identify faulty and non-functional PPE/C? yes ☐ no ☐

18) Are faulty and dysfunctional PPE/C repaired and serviced accordingly? yes ☐ no ☐

END OF INTERVIEW……. THANK YOU