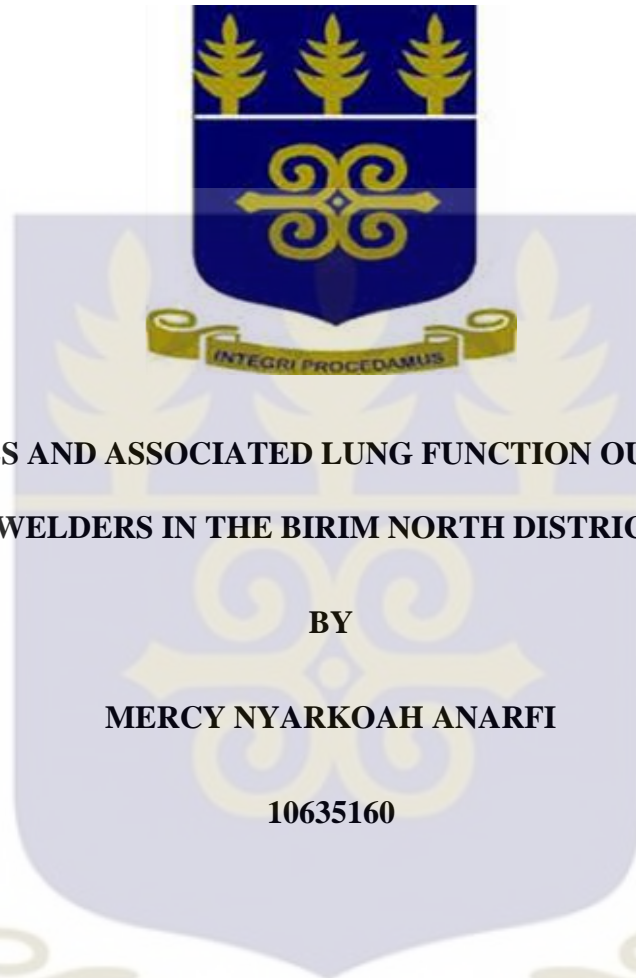


**SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
UNIVERSITY OF GHANA LEGON**



**WELDING FUMES AND ASSOCIATED LUNG FUNCTION OUTCOMES AMONG
WELDERS IN THE BIRIM NORTH DISTRICT**

BY

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10635160

**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON
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OF PUBLIC HEALTH DEGREE**

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DECLARATION

I, MERCY NYARKOAH ANARFI declare that, apart from the findings of other investigators, this is my original work. This dissertation includes nothing that is the outcome of work done in collaboration with others and is not substantially the same as any that may have been used in part or wholly for the award of any other course or degree qualification.

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MERCY NYARKOAH ANARFI

(STUDENT)

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DATE

.....

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(SUPERVISOR)

.....

DATE

DEDICATION

This work is dedicated to my wonderful parents Mr Anarfi Boateng and Mrs Josephine Asiedua Wadieh and my dear siblings Paakwasi, Emma Wadieh, and Nana Mintaah and to my cousins and friends especially Bernard Awudzi, for their immeasurable support and prayers.

Also to my dear Uncle Baah Wadieh, a big thank you for your involvement in every stage of this journey.

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Finally to my colleagues, I say thank you for your care and support.

ABSTRACT

Background: Occupational hazards account for a significant percentage of worldwide burden of disabilities and injuries. Welders are exposed to a variety of fumes during the welding process. Continuous exposure to these fume particles can pose harmful threats to the lungs of welders. This can result in a number of conditions such as metal fume fever, nose and throat irritation, bronchitis, emphysema, Chronic Obstructive Pulmonary Disease (COPD) and lung cancer thereby reducing lung function. Though a number of control measures have been recommended for reducing exposure to welding fumes among welders, most welders do not however adhere to the proper utilization of these measures and as a result, become exposed to hazards from welding fumes. **Objective:** The main objective of the study was to assess the effects of welding fumes on lung function outcomes of welders in the Birim North District.

Methodology: A Descriptive cross sectional study was conducted among welders in the Birim North District of Ghana. Interviews were conducted for welders using a structured questionnaire in gathering data from 103 respondents using census and purposive sampling. Thereafter lung function was assessed using a spirometer. Data was analyzed using STATA version 15. Chi-square test, Fishers exact test were employed in assessing associations.

Results: Prevalence of low lung function outcome among welders in the Birim North district was (4.85%) and sex was significantly associated with lung function outcome ($p=0.011$). Majority of welders were knowledgeable of the effects of welding fumes on the lungs, however utilization of PPEs to reduce fume exposure was not fully effective. This was influenced by hindrances such as cost and availability hence ($p=0.013<0.05$) was significantly associated with

lung function outcomes. Smoking ($p\text{-value} = 0.383 < 0.05$) had no significant association with lung low function outcome in this study.

Conclusion: Though the majority of welders (95.15%) had Normal lung outcome, some cases of low Lung function outcomes were also recorded among five participants (4.85%) of which three (3) were males and two (2) were females. However as this could be linked to the anatomical structure of the female lungs, since it was not influenced by factors and practices associated with welding fumes exposure. Also smoking had no influence on lung function outcome but sex was statistically significant ($p=0.011$) therefore needs to be further researched into.

LIST OF ACRONYMS

ACGIH	American Conference of Government Industrial Hygienist
COPD	Chronic Obstructive Pulmonary Disease
CI	Confidence Interval
FCAW	Flux Core Arc Welding
FEV	Forced Expiratory Volume
FVC	Forced vital capacity
GSS	Ghana Statistical Service
GHS	Ghana Health Service
KM	Kilometres
MIP	Manganese - Induced Parkinsonism
OSHA	Occupational Safety and Health Administration
PM	Particulate Matter
PPE	Personal Protective Equipment
PEL	Permissible Exposure Limit
SMAW	Shielded Metal Arc Welding
SPH	School of Public Health
TLV	Threshold Limit Values

GMAW	Gas Metal Arc Welding
SAW	Submerged Arc Welding
SQ	Square
GTAW	Gas Tungsten Inert Arc Welding
TIG	Tungsten Inert Gas
CAW	Carbon Arc Welding
PAW	Plasma Arc Welding
LBW	Laser Beam Welding
OFW	Oxyfuel Gas Welding
OH	Occupational Health
SS	Stainless Steel
OTC	Over-the Counter

TABLE OF CONTENTS

DECLARATION.....	i
DEDICATION.....	ii
ACKNOWLEDGEMENT.....	iii
ABSTRACT.....	iv
LIST OF ACRONYMS	vi
TABLE OF CONTENTS	viii
LIST OF TABLES	xii
LIST OF FIGURES	xiii
DEFINITION OF TERMS.....	xiv
CHAPTER ONE	1
INTRODUCTION.....	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Conceptual Framework	4
1.4 Justification of the study	7
1.5. Research questions	8
1.6 Objective of the study	8
1.6.1 Main objective	8
1.6.2 Specific Objectives	8
CHAPTER TWO	9
LITERATURE REVIEW	9

2.1 Introduction	9
2.2 The Effects of Welding Fumes on Lung Function of Welders	9
2.3 Knowledge of welders on the respiratory effects of welding fumes	11
2.4 Practices that expose welders to welding fumes.	12
2.5 Safety measures used by welders to reduce exposure to welding fumes	15
CHAPTER THREE	17
METHODS	17
3.1 Type of study and Design	17
3.2 Study Location/Area	17
3.3 Study Population	18
3.4 Study Variable.....	18
3.5 Sampling.....	19
3.5.1 Sample Size	19
3.5.2 Sampling Method	20
3.6 Data Collection Techniques/Methods & Tools.....	20
3.7 Quality Control.....	21
3.8 Data Processing and Analysis	22
3.9 Ethical Clearance.....	23
3.10 Pre-test.....	24
CHAPTER FOUR.....	25
RESULTS	25
4.1 Introduction	25

4.2 Demographic characteristics of respondents.....	25
4.2.1 Demographic factors associated with lung function.....	27
4.3 Interpretations of Lung function Outcomes	28
4.4 Knowledge of welders on respiratory effect of welding fumes	30
4.4.1 Association between Knowledge of welders on respiratory effect of welding fumes and lung function.....	30
4.5 Factors and practices that expose welders to welding fumes.....	31
4.6 Factors and practices that expose welders to welding fumes. (Welding Materials)	33
4.6.1 Association between factors and practices that expose welders to welding fume and lung function.....	33
4.7 Safety measures used by welders to reduce exposure to welding fumes.....	35
4.8 Other Personal Protective Equipment used by welders	37
4.8.1: Association of Safety measures used by welders to reduce exposure to welding fumes with lung function.....	38
4.9 Assessment of lung function of welders	39
4.9.1 Association of smoking and lung function.....	41
CHAPTER FIVE	42
DISCUSSION.....	42
5.1 Introduction.....	42
5.2 Demographic characteristics of respondents.....	42
5.3 Knowledge of welders on respiratory effect of welding fumes	43
5.4 The Effects of Welding Fumes on Lung Function of Welders	44
5.5 Factors and practices that expose welders to welding fumes.....	45

5.6 Safety measures used by welders to reduce exposure to welding fumes	46
CHAPTER SIX	48
CONCLUSION AND RECOMMENDATION	48
6.1 Introduction	48
6.2 Conclusion.....	48
6.3 Study limitations	49
6.4 Recommendation.....	49
6.4.1 Government/Policy Makers	49
6.4.2 Employers/Masters	50
6.5 Futher Research Areas	50
REFERENCES.....	51
APPENDICES	55
Appendix 1 Informed consent form	55
Appendix 2: Questionnaire.....	58

LIST OF TABLES

Table 1 Health effects of Welding Fumes and Gases Produced during Welding.....	13
Table 2: Demographic characteristics of respondents	26
Table 3: Demographic factors and associations with lung function	27
Table 4: Interpretations of Lung function Outcomes.....	29
Table 5: Association between Knowledge of welders on effect of welding fumes on the lungs and lung function outcome.....	31
Table 6: Factors and practices that expose welders to welding fumes.	32
Table 7: Association of factors/practices that expose welders to welding fumes with lung function.	34
Table 8: Safety measures used by welders to reduce exposure to welding fumes.	36
Table 9: Association of Safety measures used by welders to reduce exposure to welding fumes with lung function.	38
Table 10: Assessment of lung function of welders.....	40
Table 11: Association of smoking and lung function.....	41

LIST OF FIGURES

Figure 1: Conceptual Framework 7

Figure 2: Lung function Outcomes 29

Figure 3: Knowledge of welders on the effects of welding fumes on the lungs..... 30

Figure 4: Material used in welding 33

Figure 5: Other Personal Protective Equipment used by welders..... 37

DEFINITION OF TERMS

Welding: Joining together metal parts by heating the surfaces to the point of melting with a blowpipe, electric arc or other means and uniting them by pressing and hammering them.

Welding fumes: Welding fumes are a complex mixture of metallic oxides, silicates and fluorides.

Fumes are formed when a metal is heated above its boiling point and its vapours condense into very fine, particles (solid particulates). Welding fumes generally contain particles from the electrode and the material being welded.

Lungs: Is a pair of organs of the respiratory system locate within the chest cavity which removes carbon dioxide from the body and receives oxygen into the body.

Forced Vital Capacity (FVC): The total volume of air that one can forcibly exhale in one breath.

Forced Expiratory Volume in One second (FEV1): the volume of air that a person is able to exhale in the first second of forced expiration.

FEV1/FVC: the ratio of Forced Expiratory Volume in One second (FEV1) to Forced Vital Capacity (FVC).

Spirometry: it is a method of assessing lung function by measuring the volume of air that a person can expel from the lungs after a maximal breath in.

Chronic Obstructive Pulmonary Disease (COPD): it is a chronic inflammatory lung disease that causes obstruction in flow of air flow the lungs.

CHAPTER ONE

INTRODUCTION

1.1 Background

Occupational hazards account for a significant percentage of worldwide burden of disabilities and injuries (Nelson et al., 2005). Though several safety measures have been put in place in developed countries to reduce occupational hazards and injuries, there still continue to be high incidence and mortality rates across the globe.

Welding is a process that harmonises materials together by melting a metal work piece along with a filler metal to form a strong joint (Swift & Murray, 2008). The process involved in welding produces visible smokes that are composed of harmful metal fume and gas by-products. (Occupational Safety and Health Administration (OSHA, 2013).

Welding “smoke” is composed of very fine particles (fumes) and gases. Components of welding smoke include the following but not limited to chromium, nickel, arsenic phosgene, acrolein, fluorine compounds, carbon monoxide, cobalt, copper, lead, ozone, asbestos, manganese, silica, beryllium, cadmium, nitrogen oxides, selenium and zinc and these are harmful to the lungs (Baldwin, Kohli, Lee, Liu, & Zhao, 2004).

As workers inhale welding fumes, some of the particles are deposited in the airway and as they remain, they become airborne and are ex-haled (Virginia, 2015). These particles can either be seen or not and may be in a form of metallic compounds with its size being less than one micrometer (1 μm) when produced, however in the absence of fume visibility, particles still exist (Baldwin et al., 2004). Jeffus, (1999) also commented that, as time goes on, the particle size

begins to increase within a range of 1-7 micrometer and assemble together; this becomes more harmful due to its capability of entering the lungs. Welding fumes are developed based on certain welding factors which include; the current of arc used for welding, the space between the work piece and electrode, the mode of welding, the welding process and its location and the type of heat used. On the average, fume formation is affected by the amount of current, length for arc and voltage (Jeffus, 1999)

According to Li, Hedmer, Kåredal, Björk, Stockfelt, Tinnerberg, Albin & Broberg, (2015), occupational air pollution may predispose a person to chronic and high-level exposure to particulate matter (PM), therefore PM exposure in occupational setting may affect workers health with welders being at high risk. Exposure to particulate matter (PM) thus through inhalation is associated with increased risk of cardiovascular disease Shah et al., (2013). According to OSHA, (2013) acute exposure to welding gases and fumes can result in a number of conditions such as throat, nose and eye irritation, whereas prolonged exposure to welding fumes may result in chronic conditions such as lung damage and various types of cancer, involving the skin, lung, larynx and urinary tract. Also health effects from certain fumes may include metal fume fever, stomach ulcers, kidney damage and nervous system damage. Gases such as helium, argon, and carbon dioxide displace oxygen in the air and can lead to suffocation, particularly when welding in confined or enclosed spaces (Antonini, 2003).

In Ghana welding is usually learnt informally by apprenticeship and is extensively used in the mining and manufacturing industries for producing agricultural processing machinery, vehicle body structures and seat frames, burglary- protection shields, compressed gas cylinders, metal and containers. During welding, the welder and his environment are exposed to a variety of fumes and gases related to the welding process and it is important for mankind to realize the

problems that can occur during welding and how to prevent physical contact with welding fumes and gases (Adu, 2011). The use of personal protective equipment (PPE) at all times is a good and safe practice by welders to protect them from exposure to hazards and injuries during welding or cutting (Budhathoki, Singh, Sagtani, Niraula, & Pokharel, 2014).

A research conducted by Kumah, Cobbina & Duodu, (2011) in Ghana revealed that the prevalence of eye diseases among welders and control group was 65.5% and 16.9% respectively and therefore concluded that the ocular symptoms and ailments prevalent among the welders were most likely due to the radiations they are exposed to in their work environment.

In conclusion, high risk of welding fumes exposure among welders in the informal sector can result in reduced lung function and other conditions that can lead to cancer and death.

1.2 Problem Statement

Welders are exposed to a variety of fumes during the welding process. Continuous exposure to these fume particles can pose harmful threats to the lungs of welders (Nelson et al., 2005). Inasmuch as the invention of technology is helping yield solutions to some of these problems, there still continue to be high incidence and mortality rates across the globe. According to World Health Organization and International Labour Organization, 2.3 million deaths occur from reasons attributed to work annually with the largest component being work – related injuries. Work-related cancers accounted for 8.4% with 13.8% males and 2.2% females of all cancer deaths, lung cancer 3.0-2.0% male/female while respiratory system diseases also accounted for 4.1% with 6.8% being males and 1.1% females.

Most causes of mortalities due to occupational hazards associated with welding fumes can result in lung damage and various types of cancer, including the lungs and larynx thereby reducing

lung function outcomes (Occupational Safety and Health Administration (OSHA). Acquisition of training for welders in Ghana is mostly informal through apprenticeship and is extensively used in the mining industries, manufacturing industry for producing agricultural processing machinery, vehicle body structures and seat frames, burglary- protection shields, compressed gas cylinders, metal containers while others operate as small and medium scale enterprises. During welding, the welder and his environment are exposed to a variety of fumes and gases related to the welding process (Adu, 2011)

Though personal protective equipment are recommended for reducing exposure to welding fumes among welders, most welders in Ghana do not adhere to the proper utilization of these measures and as a result, they are exposed to welding hazards. In Ghana not enough measures have been put in place by Government regulatory bodies to ensure the safety of these welders as well as no enforcement of safety precautions among workers in the informal sector (Amfo-Otu & Agyemang, 2016).

The rate at which welders in the Birim North District are exposed to welding fumes are high and this can have a reduced effect on their lung function ability. This is because inadequate protective equipment and measures are being put in place during welding activities and as a result, welders end up inhaling the hazardous fumes and particulate matter. In addition most welding workshops are located close to homes and places where a lot of public activities take place and this is also posing a lot of threat to the public especially those inhabitants close by.

1.3 Conceptual Framework

This framework attempts to explain various factors that influence welders' exposure to welding fumes. Exposure to welding fumes is directly influenced by occupational factors. It is important

for welders to know the hazards associated with the welding materials they use. It is therefore expected of employers to ensure that adequate information is made available for welders and also welders are trained and supervised effectively in order to reduce exposure to welding fumes (Korczynski, 2000).

Occupational factors play major role in determining a person's exposure to welding fumes. Factors such as type of welding process will determine the type of metals to be used, duration of exposure as well as the concentration of particles inherent in the fumes. This will invariably affect the type of personal protective equipments (PPEs) to be used, level of protection and its effectiveness. Welders' knowledge on the welding fumes will also influence their practice thereby affecting their level of exposure, selection of PPEs as well as their lifestyle (OSHA, 2004).

Individual factors play a role in predisposing welders to a greater risk; these include age, gender, immunity, lifestyle (such as smoking, excessive alcohol intake) and medical history. Men are at a greater risk than women, whereas majority of welders are between the ages of 18years and 50years. A person's health status also determines his /her level of immunity.

Knowledge on the effects of welding fumes will lead to reduction in morbidity and mortality such that, early diagnosis and treatment of detected cases can be made, occupational exposure limits will be ensured and medical surveillance will also be ensured (Health & Commission, 1990). This will include pre-employment medical checks to establish baseline information, periodic and exit medicals to monitor for any deviation in health (Executive, 2002). Above all prevention of exposure will directly influence reduction in morbidity and mortality of respiratory health hazards associated with welding fumes thereby influencing lung function outcome.

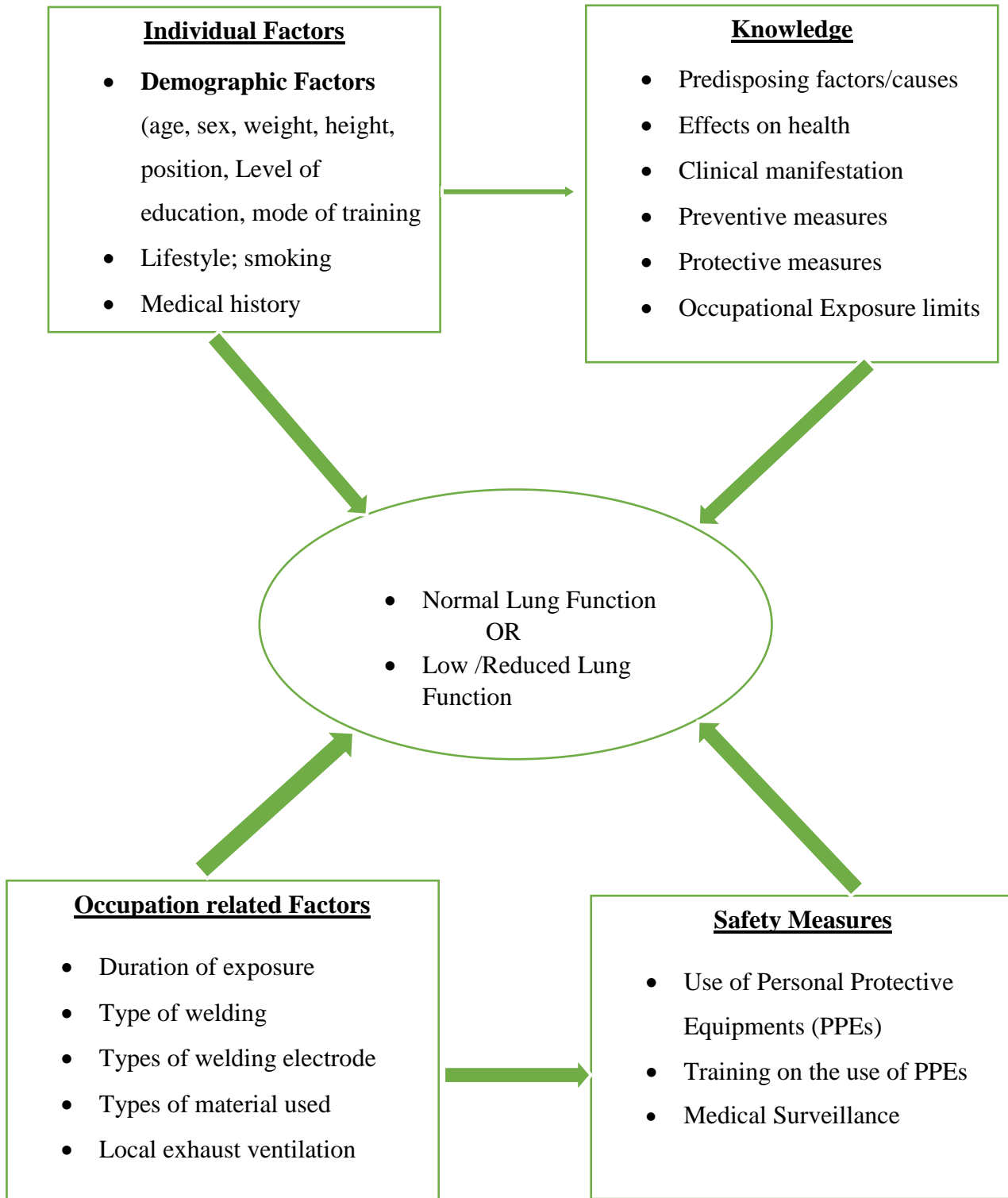


Figure 1: Conceptual Framework

1.4 Justification of the study

This study will contribute to the public awareness on exposure to welding fumes and their effects on lung function. Welding has become an important necessity in our part of the world which is widely used and this automatically exposes welders to hazards associated with it. For welders to be healthy while they continue to carry out their duties, it will be of great importance for them to ensure adequate protective measures in order to prevent or minimize exposure (Executive, 1998). It requires considerable knowledge to know the composition of the types of welding metals and equipments being used and their effects, occupational exposure limits, types of personal protective equipments and their level of protection.

Apart from occupational exposure, welders need to be aware of other individual factors that can put them at more risk compared to non-welders such as age, lifestyle (excessive alcohol intake and smoking) and medical history, which the results of this study seeks to reveal. Assessing the respiratory effects of welding fumes on welders will help expose the extent to which welders' lives are jeopardized as well as identifying inappropriate measures used by welders in all sectors ranging from small scale to large scale. Data from this research will help identify personnel, organizational and technical short falls in the welding industries and ensure that strict measures are enforced to protect welders in the country. Above all it will help advocate for support groups for welders including policy makers, educators and an organizational body that can be a mouthpiece for welders in Ghana right from local to the national level. Occupational health policy will provide some evidence in policy making thus rather for this large occupational group from the informal sector of the Ghanaian economy.

1.5. Research questions

- What are the effects of welding fumes on the lung function of welders in the Birim North District?
- What is the level of knowledge of welders on the effects of welding fumes on the lungs?
- What are the factors and practices that expose welders to welding fumes?
- What are the safety measures used by welders to reduce exposure to welding fumes?

1.6 Objective of the study

1.6.1 Main objective

The main objective of the study is to assess the effects of welding fumes on lung function of welders in the Birim North District using a spirometer.

1.6.2 Specific Objectives

- To assess the level knowledge of welders on the effects of welding fumes on the lungs.
- To identify practices that expose welders to welding fumes.
- To identify safety measures used by welders to reduce exposure to welding fumes.
- To measure indicators of lung function using a spirometer.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter seeks to review previous researches conducted in relation to this research. This literature review is discussed under the following themes below:

- The Effects of Welding Fumes on Lung Function of Welders
- Knowledge of welders on the respiratory effects of welding fumes
- Practices that expose welders to welding fumes
- Safety measures used by welders to reduce exposure to welding fumes

2.2 The Effects of Welding Fumes on Lung Function of Welders

The health effects of welding exposures are difficult to list, because the fumes may contain so many different substances that are known to be harmful. The route of exposure of the fumes is by inhalation of welding fumes or gases and this can cause serious health hazards to the individual depending on the type of fume inhaled and the health status of the individual (Baldwin et al., 2004). This exposure have either short term (acute) health effect or long term (chronic) health effects on a person. According to (OSHA, 2013) the most common acute effect of exposure to welding fume is called Fume Fever with symptoms similar to common flu; chills, low level fever, fatigue, nausea, sore throat, body aches and pains usually lasting 24 hours. Zinc, the coating used in galvanized metal, is often associated with Metal Fume Fever but most other forms of welding fume exposure have also been implicated.

Chronic effects of exposure to the variety of welding elements can take the form of many serious illnesses including Chronic Obstructive Pulmonary Disease (COPD), irritation of the airway emphysema or chronic bronchitis and lung cancer however prolong duration of exposure plays a role (Antonini, 2003). Studies have shown that welders are 25%-40% risk of developing lung cancer based on a study “Welding and Lung Cancer in Central and Eastern Europe and United Kingdom” results indicated that occupational exposure to welding fumes was responsible for 4% of lung cancer cases among 2,197 welders (’t Mannetje et al., 2012).

A study conducted by AlOtaibi, (2014) to identify respiratory symptoms and function of welders revealed chronic respiratory diseases among welders compared to the non-exposed group and also, spirometry findings showed that there was no impairment in lung function of both welders and non-exposed group in Saudi Arabia. Also results from a meta-analysis study by (Sjogren, Hansen, Kjuus, Persson, & Sjdgren, 1994) indicated that, there was an association between stainless steel welding fumes and lung cancer after confounding for smoking and exposure to asbestos.

However, a study by Sharifian, Loukzadeh, Shojaoddiny-Ardekani, & Aminian, (2010) in Iran revealed lower pulmonary function levels after spirometry in welders as compared to controls with dose-effect relationship between welding duration and decreased pulmonary function impairment which indicate that welders were more susceptible to pulmonary diseases after investigating for the effects of welding fumes on the lungs and respiratory symptoms.

Findings from a research by Golbabaie et al., (2013) are in accordance with the above studies as it also unearthed that, there was a decrease in pulmonary function among welders and this was associated with welding. However a prospective study conducted by (Christensen, Bonde, & Omland, 2008) revealed that, decline in lung function of welders was not related to the cumulated welding particulate exposure during follow-up period.

2.3 Knowledge of welders on the respiratory effects of welding fumes

Welding is an activity that requires special skills and knowledge. It is therefore important for all welders to be well informed of the hazards associated with the various welding processes, electrodes, currents, and substances used. Welding skills and training may be acquired formally through an institution such as vocational, technical and colleges or learnt on the job. Most employers prefer to employ welders who are already experts in formal training (Adu, 2011). The study conducted by (Tijani , Adetutu, Oloyede , & Aderemi ., 2014) showed that welders with post-secondary education and longer working experience were knowledgeable about welding fume hazards therefore adhered to the use of safety devices compared to those with lower educational background and experience.

Also, Budhathoki, Singh, Sagtani, Niraula, & Pokharel, (2014) in their study unearthed that majority of welders 90% were aware of at least one hazard associated with welding. Whereas only 47.7% were aware of the use of personal protective equipments (PPEs) but it was realized that education and duration of employment played significant roles because those who used PPEs were those aware of welding hazards. Another research by Arts & Nadu,(2010) revealed that out of the 330 participants, 77.9% of them were aware of one or more occupational hazards associated with welding however it was influenced by educational level, training and work

experience. Either way workers should be well trained to carry out their activities diligently with minimal hazards to themselves and others affected by their welding activities. It is the duty of employers to ensure that all their employees or apprentices are well informed of the effective use and maintenance of PPEs and also refer to material safety data sheets before using certain materials for example fluxes, electrodes and coatings (Klaus Kuhl,; Carsten Brück, 2017).

2.4 Practices that expose welders to welding fumes.

A study was conducted by Lillienberg et al., 2008) in Europe to look out for specific welding risk factors responsible for increasing certain respiratory symptoms and results proved that there was a significant relationship between welding with galvanized and stainless-steel materials and chronic bronchitis. Another cross-sectional study by (Qin et al., 2014.) to identify factors influencing the Health Related Quality of Life of welders revealed that welders had worse quality of life especially carbon-dioxide arc welders were deeply affected. According to (Health & Commission, 1990) Local Exhaust Ventilation was not effective in influencing ozone due to formation of gas away from arc. To disprove this, recent review of literature by (Flynn & Susi, 2012) disclosed that Local Exhaust Ventilation can decrease exposure to welding fumes below acceptable levels. According to studies, symptoms produced from the effect of welding fumes largely depend on the following: the amount and type of metals and gases found in welding fumes, which is also dependent on the welding process and base metal used (Zimmer and Biswas, 2001).

Table 1 Health effects of Welding Fumes and Gases Produced during Welding.

Fume Component	Source of Metal	Effects and Symptoms
Aluminium	Alloys such as Zinc, copper, brass, magnesium, steels	Irritation of the respiratory tract.
Beryllium	Solified compounds in copper, aluminium alloys, electrical	Metal fume fever.
Cadmium Oxide	Coatings on stainless steels,	Irritation of the respiratory passage way, pain in the chest, Dyspnea, bronchitis, chemical pneumonia, pulmonary edema, emphysema. Prolong exposure causes damage to kidney and lungs.
Chromium	Stainless steel, chrome alloy – electrodes, welding rods	Irritation of the skin, asthma, high predisposition to lung cancer.
Copper	Brass, bronze and monel alloys, certain types of welding rods	Metal fume fever
Fluorides	Flux materials from MMAW, FCAW,SAW,GMAW,and electrode coatings.	Eye, throat, skin and nose irritation, chronic fluorocosis syndrome
Iron-oxide	All ferrous metals	Siderosis (an acute lung disease resulting from accumulation of iron oxide particles in the lung. Resolves when there's no exposure.
Lead	Bronze solder and brass alloys, coatings on steel.	Lead poisoning, Prolong effect on the gastrointestinal tract, kidneys, blood, and brain.
Manganese	Majority of welding processes	Metal fume fever, inflammation of the lungs. Central nervous system disorders result from prolong effects.
Molybdenum	Stainless steel, steel alloys, iron, nickel iron	Dyspnea, bronchial irritation and Liver dysfunction in severe.
Nickel	Stainless steel, welding electrodes	Irritation of the respiratory tract, susceptibility to cancer has also been found

Vanadium	Filler wires, alloy steels, iron, stainless steels.	Short-term effects are irritation of the respiratory tract. Long-term effects include emphysema, bronchitis and Chemical pneumonia,
Silica	Flux-cored electrode, coatings on metal electrodes	Silicosis
Zinc-oxide	Galvanized steels and coated metals	Metal fume fever and zinc chills
Cobalt	Alloys	Shortness of breath, pneumonitis and cough. Symptoms however cease when exposure ends.
Carbon dioxide	Arc welding in confined space	Asphyxia
Nitrogen dioxide	Formed in the welding arc	Accumulation of fluid in the lung, irritation of nose, eye and throat. Chronic conditions include emphysema.
Carbon monoxide	Formed in the welding arc	Drowsiness, nausea, headache and unconsciousness in cases of over exposure.
Ozone	Formed in the welding arc mostly in MIG, plasma-arc welding and GMAW	Accumulation of fluid occurs in the lungs and irritation of the upper respiratory tract.
Hydrogen	Decay of rod coatings	Irritation of the respiratory tract, lung damage.
Phosphine	Metal coated with rust inhibitors	Irritation of the respiratory tract and lung damage
Phosgene/ carbonyl chloride	Metals with Residual decreasing solvents Formed when chlorinate hydrocarbons oxides.	Irritation of the eyes and respiratory tract. Has a delayed onset of symptoms.
Insufficient oxygen	Welding in confined environment	Confusion, asphyxia, dizziness and death.

Sources: (Kielhorn et al., n.d.; Swift & Murray, 2008.; Baldwin et al., 2004.; (Health & Commission, 1990).

2.5 Safety measures used by welders to reduce exposure to welding fumes

Occupations that predispose workers to hazard require certain responsibilities to be taken in order to protect workers. These measures however, are not strictly implemented but rather resort to the utilization of personal protective equipments which may intend yielding partial levels of control (Spee, Van Duivenbooden, & Terwort, 2006). This has led to the development of standardized measures to be taken in ensuring the health and safety of workers in all occupation which is often referred to as “Hierarchy of Controls” by OSHA. The hierarchy involves five steps in order of priority; elimination, substitution, engineering controls, administrative controls and use of personal protective equipments. The goal is to get rid of occupational diseases, injuries and predisposing factors as much as possible (Klaus Kuhl & Carsten Brück, 2017). A study by Tijani , Adetutu, Oloyede , & Aderemi ., (2014) in Osogbo Osun state, Nigeria, revealed that, a greater percentage of the 110 welders lacked knowledge on the use of safety devices and their influence on occurrence of occupational hazards. However another research was conducted by Rasaan Adewoye et al., (2013) in Ilorin South Local Government Area, Nigeria to ascertain the knowledge of welders on health implication of welding smoke and use of PPE showed that, there was a significant association between the knowledge on health effects of welding smoke and the use of face-mask and eye-goggles during welding activities. Out of the 285 respondents 45.5% used face mask whereas 52.3% also used eye-goggles.

Further research by (Jessy, 2015) in Zambia to identify occupational hazards and their use of personal protective equipment among welders revealed that poor housekeeping and unsafe work structures and tools were also contributory factors hazard exposure and to add to it none of the welders used all recommended PPE at any time during welding even though majority of them were aware of one or more PPEs. Again, investigations by Amfo-Otu & Agyemang, (2016) in

Ghana showed most auto mechanics of which welders were part did not realize the essence of using PPEs for their own safety as this could contribute to hazards and disease and therefore recommended the involvement of Government and stakeholders in establishing Occupational health and safety measures to support informal auto-mechanics in order to minimize the risk associated with their work.

In conclusion welding involves activities, processes and substances that put welders at higher risk in terms of their health. Health surveillance may be mandatory for workers exposed to certain occupational hazards such as fumes, noise, vibration, biological agents and other harmful substances. It is also necessary to have measures in place to monitor welders' health in order to detect early symptoms and treat (Executive, 2002). Welders should undergo periodic medical checks to assess lung function, hearing, vision other investigation. Medical record should be well monitored and protected to be able to rule out occupational factors responsible for illness. Biological monitoring should be done for particular exposures (Health & Commission, 1990).

CHAPTER THREE

METHODS

3.1 Type of study and Design

This study is a quantitative study using structured questionnaires with measurement of lung function. This study was conducted as a descriptive cross-sectional study to assess the effects of welding fumes on the lung function outcomes of welders within the Birim North District. It also assessed the level knowledge of welders on the respiratory effects of welding fumes, identified practices that exposed welders to welding fumes as well as safety measures used by welders to reduce exposure to welding fumes.

3.2 Study Location/Area

The study was conducted in selected communities within the Birim North District of the Eastern Region where welders were found. Welders were directly interviewed at their workshop, after which lung function test was done using a CONTEC SP10 Hand-held spirometer.

The Birim North District is one of the twenty one districts in the Eastern Region of Ghana. It has a population of 78,907 with a representation of 3.0% of the region's population (Ghana Statististal Service , 2012). However the projected population for 2017 is 91,402. The district is made up of seventy eight communities with New Abirem being the capital. It occupies a land area of approximately five hundred and fifty squared kilometers (550sq/ km). The district shares boundaries with seven districts. Atiwa and Kwaebibirem districts in the Eastern part, Kwahu – West district in the Northern part, Adansi -South, Amansie- East and Asante Akim -South districts in the Western part and then Birim South district in the southern part respectively.

The main occupations of the people are farming and small scale mining. Others are involved in some informal activities such as welding, carpentry, fabrication, masonry, tailoring, hairdressing, automobile repairs etc. According to the Ghana statistical report 2012, about 52.0% of the population are involved in skilled agriculture, fishery and forestry, 14.1% in sales and services, 6.9% as technicians and professional and the remaining 12.9% are involved in trade and craft (GSS, 2012)

This study site was selected due to its involvement in mining and farming activities which has led to rapid growth and development of the district. Also there's been increased in production of machinery and equipments especially by welders to assist both small and large scale farmers and miners to increase their productivity.

3.3 Study Population

The study population comprised of welders both apprentices and masters within selected communities in the Birim-North District. Eligibility criteria included welders aged eighteen (18) years and above with more than six months working experience within selected communities where welders were found in the Birim North District

3.4 Study Variable

Outcome variable was lung function outcome of welders. This was assessed using a CONTEC SP10 Hand-held spirometer to measure inspiratory and expiratory capacity such as Forced expiratory volume in one second (FEV1), Forced vital capacity (FVC) and FEV1 divided by FVC (FEV1/FVC).

Independent variables included:

- Demographic characteristics of welders: age, sex, weight, height, position, level of education, mode of training, lifestyle; smoking medical history.
- Occupational factors and practices: types of welding, duration of exposure, type of welding electrodes used, type of metal being welded, ventilation system and concentration of fumes.
- Safety measures: Use of Personal Protective Equipments (PPEs), training on the use of PPEs, medical surveillance.
- Knowledge on the effects of welding fumes; Predisposing factors/causes, effects on health, clinical manifestation, preventive measures, protective measures, occupational Exposure limits.
- Hazards associated with welding process

3.5 Sampling

3.5.1 Sample Size

The sample size was calculated using the formula $n = (z^2 pq) / e^2$ with a confidence interval of 95% with 0.04 margin of error or desire level of precision (Phrasisombath, 2009). An estimate of 103 was arrived including 7% non-response.

$$\text{Sample size } (n) = (z^2 pq) / e^2 = 1.96^2 [(0.5(1-0.5)) / 0.01^2 = 96.04$$

Where $Z = 1.96$ (confidence interval of 95%)

$p = 0.50$ (Estimated proportion of the target population)

$q = 1 - p$ (1-0.5) (Proportion in the target population not welders)

$e = 0.01$ (margin of error)

3.5.2 Sampling Method

The first stage involved selection of fifteen (15) towns within the Birim North District using the purposive sampling which is a non- probability sampling method. Selection of communities was informed by where welding workshops were available with welders working in them.

The second stage of the sampling process involved selection of research participants (welders) and this was done using Census to register all welders, a method that ensures that the whole population of welders were selected. Every welder found in a welding workshop was selected after permission was sought from the head of the workshop (Master).

3.6 Data Collection Techniques/Methods & Tools

Quantitative data was collected using structured and structured questionnaire. The questionnaire was structured into five sections. Section A focused on the demographic characteristics of welders. Section B focused on assessing the knowledge of welders on the respiratory effects of welding fumes, whereas the third section, C assessed factors and practices that exposed welders to the fumes. The fourth thus D section focused on the safety measures used by welders to reduce exposure to welding fumes whereas the last section E assessed the lung function of welders.

Eligible members were interviewed and participated in the lung function test upon acceptance. Interviews were conducted for welders at their workshops by principal investigator and research assistants using the designed questionnaire. Each interview section lasted for about 10-20 minutes. Thereafter, lung function test (spirometry) was done for participants at their workshops.

A CONTEC SP10 handheld spirometer was used to assess lung function and this took about 10-15 minutes for each participant following this procedure. Participant will insert the Mouth piece of the spirometer into the mouth with lips sealed around it and nose held to prevent air from escaping. Participant was then instructed to take in a quick deep breath and blow out hard and fast. Participant was instructed to breathe in again through the mouth and remove the mouth piece from your mouth and relax. Complete test series consisted of 3 – 8 blows. Participants needed at least 3 blows within the acceptable limits with 2 repeatable tests. Participants who were unable to get 3 acceptable blows, were made to blow up to 8 times. Interpretation of spirometry values involved looking at the absolute values of Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV1) in one second and the ration of FEV1/FVC.

After blowing, predicted values of Forced Vital Capacity (FVC): The total volume of air that a person can forcibly exhale in one breath, Forced Expiratory Volume in One second (FEV1): the volume of air that a person is able to exhale in the first second of forced expiration and FEV1/FVC: thus ratio of Forced Expiratory Volume in One second (FEV1) to Forced Vital Capacity (FVC) were calculated for each individual varying with age, sex, height, weight and race (Miller et al., 2005).

3.7 Quality Control

To ensure the accuracy and validity of data, research assistants were well educated and oriented on how to interview welders using the questionnaire and input data. Also questionnaire were translated into the local language during training and administration during interviews to ensure proper understanding of all variables in the context. The lung function test (spirometry) was conducted by a qualified health professional who has been trained and possess the necessary

skills. The CONTEC SP10 spirometer was also calibrated before using to assess lung function. Readings were taken about 3-8 times to ensure accuracy. Questionnaires received were scrutinized before validating to ensure completeness and accuracy.

3.8 Data Processing and Analysis

After data collection, completeness of all questionnaires and tests conducted were carefully crosschecked. Collected data was carefully scrutinized, validated, coded and entered onto Statistical Package for Social Sciences (IMB SPSS Statistic 20). Exportation of the dataset from SPSS to Stata version 15 was done for analysis. Double data entry was done to crosscheck and prevent errors. Data was organized by running frequencies.

Descriptive statistics was run for the various categorical data. Charts, percentages, tables and frequencies were used to present them. Relationship between the dependent and independent variables were established using Chi-square test. P-Value of 0.05 was used to assess the probabilities associated with the test statistics in order to determine whether observed difference are real or due to chance. The Fisher's Exact test was used to determine the strength of the association between demographic factors associated with lung function, factors/practices that expose welders to welding fumes with lung function as well as safety measures used by welders to reduce exposure and lung function outcomes. Confounding was done to identify variables that could influence the outcome variable. Age and lung function (FEV1, FVC, and FEV1/FVC), Smoking and lung function (FEV1, FVC, and FEV1/FVC). Duration of work and lung function (FEV1, FVC, and FEV1/FVC) sex and lung function. (FEV1, FVC, and FEV1/FVC) as well as Knowledge and lung function. Lung function outcome was either Normal or Low.

Knowledge was scored using a knowledge scale (0-20) ranging from excellent to poor.

3.9 Ethical Clearance

Ethical clearance was obtained from Ghana Health Service Ethical Review Board through the School of Public Health. Permission was sought from the District Health Directorate, Ghana Health Service, Birim North District. Permission was also sought from the leaders of the District's association of artisans of which the welders belong. Written informed consent (Appendix 1) was sought from welders before administering questionnaires. Adequate information was given to study participants regarding the purpose of the study, processes and tests to be conducted and participants were given the opportunity to ask questions. Information was communicated in local languages understood by participants as it addressed issues such as, confidentiality: Participant names were not indicated on any of the questionnaires and during the lung function test, a screen was provided to ensure privacy whereas test results were communicated to participants individually. Also information obtained was kept confidential and accessible to only the research supervisor. Inputted data on the computer was protected by a password and known by only the principal investigator.

Potential risks included exertion after subsequent blows whereas potential benefits included interpretation of test results to participants, education of welders to take precautionary measures to prevent hazards associated with welding fumes as well as assisting those with respiratory and lung disorders to seek early medical attention. Participation was voluntary and one could choose to withdraw at any time. Refusal to be part did not attract any fine, loss or penalty. Participants did not receive any compensation from this study however participants were provided with snacks after the test.

Also the process involved in performing lung function test (spirometry) was explained and demonstrated to participants before the start of the test.

3.10 Pre-test

A pilot study was conducted among ten (10) welders in Dansoman located within the Ablekuma-West District of Greater Accra Region to pre-test the questionnaire drafted. This was to assess the feasibility and answerability of the questions as this facilitated amendment of the questions where needed.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter deals with presentation of results of analyzed data in order to set the stage for the discussion of research findings. Descriptive statistics and associations between outcome and exposure variables are interpreted below according to research objectives.

4.2 Demographic characteristics of respondents

From table 2, out of the (100%) respondents, (41.75%) were between the ages of 18-24 years while the least (6.80%) was recorded for the age category 36 and above, out of which (96.12%) were males and the remaining (3.88%) were females. With regards to marital status, (66.02%) respondents were single while (33.98%) were married.

Apprenticeship was the major mode of training with (93.2%) respondents while (6.80%) respondent received welding training through technical/vocational education.

Furthermore, regarding the position held by the respondents, majority (52.43%) respondents were apprentices, (33.98%) respondents were masters while (13.59%) respondents were employees. Majority of the respondents (90.29%) were working in Private/informal sectors while (9.71%) worked in Formal sectors.

Table 2: Demographic characteristics of respondents

Characteristics	Frequency	Percentage (%)
Age		
18-24	43	41.75
25-30	34	33.01
31-35	19	18.45
36 and above	7	6.80
Sex		
Male	99	96.12
Female	4	3.88
Marital status		
Single	68	66.02
Married	35	33.98
Level of education		
None	3	2.91
Primary	15	14.56
J.H.S	68	66.02
S.H.S	14	13.59
Technical/Vocational	3	2.91
Mode of training		
Apprenticeship	96	93.20
Technical/Vocational	7	6.80
Income level/Month		
>GHS 500	74	71.84
GHS 500-1000	17	16.50
GHS 1001-2000	7	6.80
Above GHS2000	5	4.85
Position		
Master	35	33.98
Employee/Worker	14	13.59
Apprentice	54	52.43
Place of work		
Industry/Formal	10	9.71
Private/Informal	93	90.29

4.2.1 Demographic factors associated with lung function.

Table 3 presents information on chi-square test investigating the association between demographic factors and lung function. The results indicated that sex of respondents ($p=0.011$) is significantly associated with lung function. However, age, marital status, educational level, mode of training, income level, and position held, and place of work were not statistically associated with lung function.

Table 3: Demographic factors and associations with lung function

Characteristics	Low	Normal	χ^2	P-value
Age				
18-24	3 (6.98)	40 (93.02)	3.83	0.26
25-30	0 (0.00)	34 (100.00)		
31-35	2 (10.53)	17 (89.47)		
36 and above	0 (0.00)	7 (100.00)		
Sex				
Male	3 (3.03)	96 (96.97)	18.36	0.01
Female	2 (50.00)	2 (50.00)		
Marital status				
Single	5 (7.35)	63 (92.65)	2.70	0.16
Married	0 (0.00)	35 (100.00)		
Level of education				
None	0 (0.00)	3 (100.00)	1.39	0.86
Primary	0 (0.00)	15 (100.00)		
J.H.S	4 (5.88)	64 (94.12)		
S.H.S	1 (7.14)	13 (92.86)		
Technical/Vocational	0 (0.00)	3 (100.00)		
Mode of training				
Apprenticeship	5 (5.21)	91 (94.79)	0.38	1.00
Technical/Vocational	0 (0.00)	7 (100.00)		
Income level				
>GHS 500	5 (6.76)	69 (93.24)	2.06	0.78
GHS 500-1000	0 (0.00)	17 (100.00)		
GHS 1001-2000	0 (0.00)	7 (100.00)		
Above GHS2000	0 (0.00)	5 (100.00)		
Position				
Master	0 (0.00)	35 (100.00)	4.77	0.16

Employee/Worker	0 (0.00)	14 (100.00)		
Apprentice	5 (9.26)	49 (90.74)		
Place of work				
Industry/Formal	0 (0.00)	10 (100.00)	0.57	1.00
Private/Informal	5 (5.38)	88 (94.62)		
Knowledge level				
Excellent	3 (4.48)	64 (95.52)	0.36	0.72
Good	2 (6.25)	30 (93.75)		
Average	0 (0.00)	4 (100.00)		

Note: P-value = Fisher's exact, χ^2 =chi-square

4.3 Interpretations of Lung function Outcomes

Among the lung function parameters represented in table 4, FEV1 results indicated that (33.01%) were normal, 35 (33.98%) were mildly abnormal forming the majority, (27.18%) were moderately abnormal, (3.88%) were moderately-severely abnormal while (1.94%) were severely abnormal. In addition, (51.46%) of respondents had abnormal FEV values as (48.4%) has normal FEV values. Furthermore the ratio of FEV1/FVC showed normal among the majority thus (69.90%) and (30.01%) formed the minority.

However the overall lung function outcome of welders revealed that majority (95.15%) of respondents had Normal lung function whereas the minimum group (4.85%) of respondents had Low lung function outcome as represented in the figure 2 below.

Table 4: Interpretations of Lung function Outcomes

Characteristics	Interpretation	Frequency	Percentage (%)
FEV1			
80% or above	Normal	34	33.01
79-70%	mildly abnormal	35	33.98
69-60%	Moderately abnormal	28	27.18
59-50%	Moderately-severely abnormal	4	3.89
49-35%	Severely abnormal	0	0
>35%	very severely abnormal	2	1.94
FVC			
80% or above	Normal	50	48.54
Less than 80%	Abnormal	53	51.46
FEV1/FVC			
70% or above	Normal	72	69.9
Less than 70%	Abnormal	31	30.01
Lung Function			
	Normal	98	95.15
	Low (COPD)	5	4.85

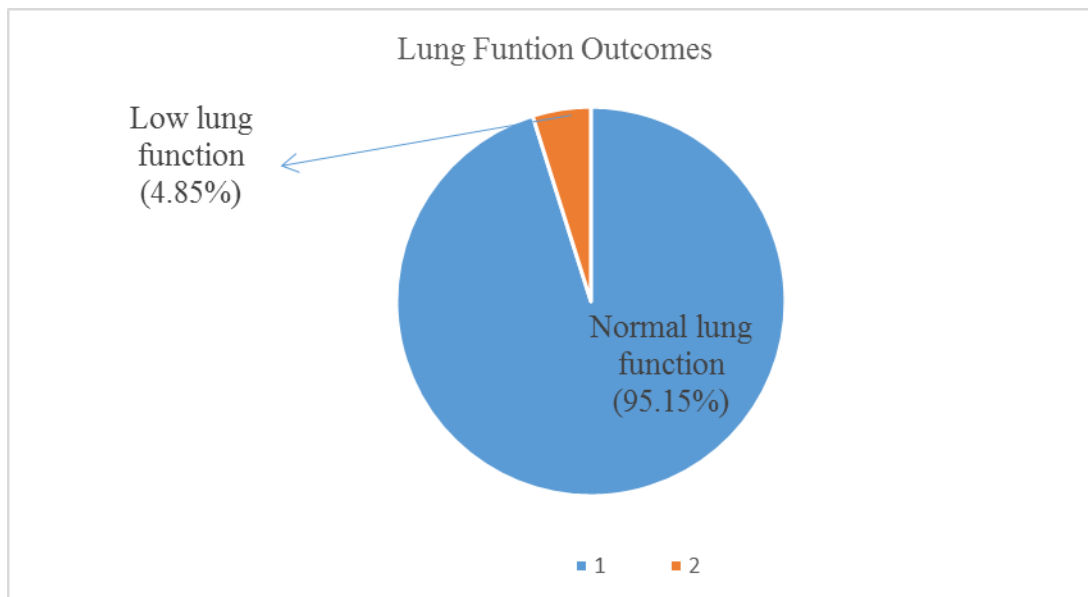


Figure 2: Lung function Outcomes

4.4 Knowledge of welders on respiratory effect of welding fumes

From the figure 3 below, out of the 103 respondents, 65.05 % of them had excellent knowledge about respiratory effects of welding fumes, 31.07% had good knowledge whereas 3.88% have average or no knowledge about respiratory effects of welding fumes.

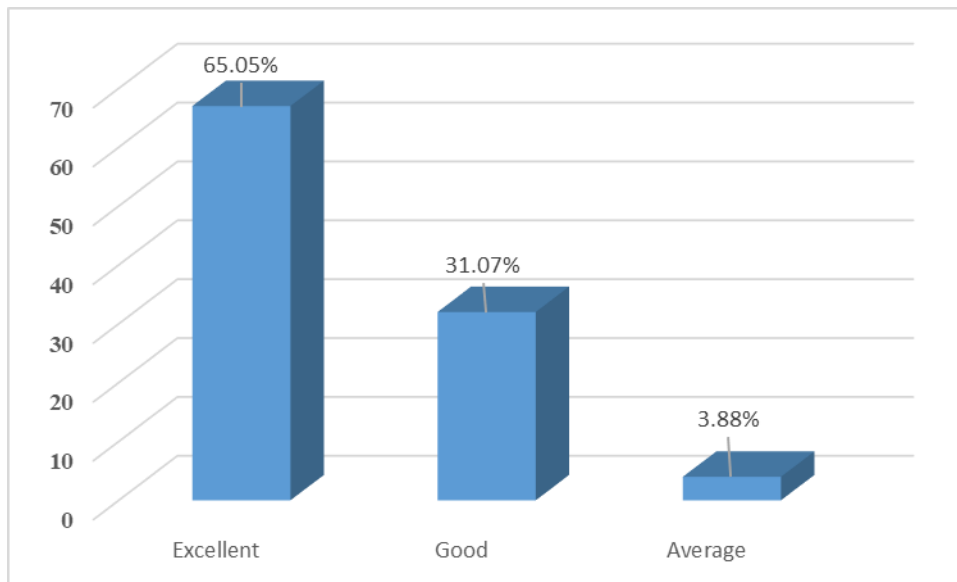


Figure 3: Knowledge of welders on the effects of welding fumes on the lungs

4.4.1 Association between Knowledge of welders on respiratory effect of welding fumes and lung function

Table 5 presents information on chi-square test the association between knowledge of welders and lung function outcome. The results show that respondents' level of knowledge had no significant influence on lung function ($p > 0.72$).

Table 5: Association between Knowledge of welders on effect of welding fumes on the lungs and lung function outcome

Characteristics	Low	Normal	χ^2	P-value
Knowledge				
Excellent	3 (60.00)	64 (65.31)	0.36	0.72
Good	2(40.00)	30 (30.06)		
Average	0(0.00)	1 (1.02)		

Note: P-value = Fisher’s exact, χ^2 =chi-square

4.5 Factors and practices that expose welders to welding fumes.

The result presented in table 6 below indicates that, majority (84.47%) of the welding shops are located in open places whiles (15.53%) are located in confined places. With regard to working period, (48.54%) respondents have worked between 1-5 years, (16.5%) respondents worked between 10-20years while the minority (10.68%) worked for less than a year. The working hour per day as reported by (84.47%) respondents was between 9-12 hours and (1.94%) respondents work less than 6 hours in a day. Electric Arc is the most common welding type performed by majority (81.55%) of the respondents whiles (10.68%) respondents perform gas welding whereas (7.7%) performed both gas and electric arc welding. On average, (38.83%) respondents spend between 4-6 hours on welding and (5.83%) respondents said it depends on the quantum of work available. On the type of electrodes used in welding, the majority (83.50%) respondents used consumable electrodes while (8.74%) respondents used Non-consumable electrodes. Most of the welders (94.17%) interviewed said they do not have any form of local exhaust ventilation.

Table 6: Factors and practices that expose welders to welding fumes.

Characteristics	Frequency	Percentage (%)
Location of workshop		
Confined place	16	15.53
Open place	87	84.47
Work Experience		
Less than 1 year	11	10.68
1-5 years	50	48.54
6-10 years	25	24.27
10-20 years	17	16.50
Shift Per Day		
Less than 6 hours	2	1.94
6-8 hours	14	13.59
9-12 hours	87	84.47
Type of welding		
Electric Arc welding	84	81.55
Gas welding	11	10.68
Both	8	7.77
Time spent on welding in a day		
Less than 1 hour	10	9.71
1-3 hours	21	20.39
4-6 hours	40	38.83
Greater than 7 hours	26	25.24
Depending on the work available	6	5.83
Electrode type use in welding		
Consumable electrode	86	83.50
Non-consumable electrode	9	8.74
Both	8	7.77
Availability of Local exhaust ventilation		
Yes	6	5.83
No	97	94.17

4.6 Factors and practices that expose welders to welding fumes. (Welding Materials)

From figure 4 the major material (41.99%) use in welding is stainless steel, galvanize (26.44%) is the second major material used. Aluminium and Iron are the third major material use and Ardox being the least material (0.43%) use in welding among the respondents.

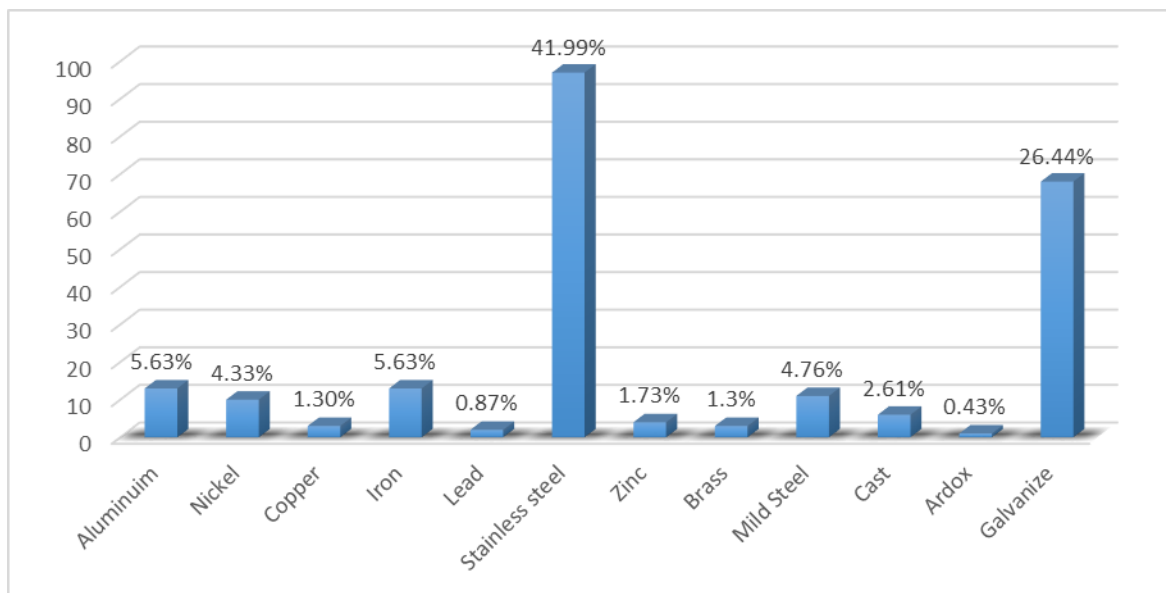


Figure 4: Material used in welding

4.6.1 Association between factors and practices that expose welders to welding fume and lung function.

Table 7 presents information on chi-square test assessing the association between factors and practices that expose welders to welding fumes and lung function. The results indicated that all characteristics, location of workplace, working period, working period, type of welding, time spent on work in a day, electrodes use in welding, and availability of exhaust ventilation were not statistically associated ($p > 0.05$) with lung function.

Table 7: Association of factors/practices that expose welders to welding fumes with lung function.

Characteristics	Low	Normal	χ^2	P-value
Location of workshop				
Confined place	1 (6.25)	15 (93.75)	0.08	0.58
Open place	4 (4.60)	83 (95.40)		
Working Period				
Less than 1 year	0 (0.00)	11 (100.00)	5.57	0.27
1-5 years	5 (10.00)	45 (90.00)		
6-10 years	0 (0.00)	25 (100.00)		
10-20 years	0 (0.00)	17 (100.00)		
Working Hours				
Less than 6 hours	0 (0.00)	2 (100.00)	0.27	0.58
6-8 hours	1 (7.14)	13 (92.86)		
9-12 hours	4 (4.60)	83 (95.40)		
Type of welding				
Electric Arc welding	4 (4.76)	80 (95.24)	0.84	0.65
Gas welding	1 (9.09)	10 (90.91)		
Both	0 (0.00)	8 (100.00)		
Time spent on welding in a day				
less than 1 hour	0 (0.00)	10 (100.00)	6.19	0.27
1-3 hours	3 (14.29)	18 (85.71)		
4-6 hours	2 (5.00)	38 (95.00)		
greater than 7 hours	0 (0.00)	26 (100.00)		
Depending on the work available	5 (4.85)	98 (95.15)		
Electrode type use in welding				
Consumable electrode	4 (4.65)	82 (95.35)	1.18	0.60
Non-consumable electrode	1 (11.11)	8 (88.89)		
Both	0 (0.00)	8 (100.00)		
Availability of exhaust ventilation				
Yes	0 (0.00)	6 (100.00)	0.33	1.00
No	5 (5.15)	98 (95.15)		

Note: P-value = Fisher's exact, χ^2 =chi-square

4.7 Safety measures used by welders to reduce exposure to welding fumes.

From table 8, out of the respondents, (62.14%) respondent were trained on the use of PPEs while (37.86%) said they did not receive any training out of which (41.74%) respondents made use of protective clothings, whereas (50.49%) respondents do not use protective clothings and the remaining (7.77%) said they seldomly made use them. Majority of the respondents (71.7%) respondent used face mask, (20.75%) respondents used respirators while (7.55%) respondents used both face mask and respirators. It is impressive that majority (98.02%) respondents were aware of the importance of using of PPEs in reducing exposures however, cost was identified as the leading (70.89%) limiting factor to the usage of protective materials. Majority of welders (41.75%) said they buy medicine from the drug store when they are affected by the welding fumes, (25.24%) respondents take some rest and continue, (20.39%) respondents said they don't do anything ,however only (9.71%) go to the hospital for treatment. Majority of welders (56.86%) do not go for medical check-up, (28.43%) go for medical check-up only when they are sick, (6.86%) go for check-up every six month, (4.9%) once in a year with the minimum (2.94%) 2 years and above.

Table 8: Safety measures used by welders to reduce exposure to welding fumes.

Characteristics	Frequency	Percentage (%)
Trained on use of PPEs		
Yes	64	62.14
No	39	37.86
Usage of Respiratory Protective Equipments		
Yes	43	41.75
No	52	50.49
Sometimes	8	7.77
Type of Respiratory Protective Equipments		
Face mask	38	71.70
Respirators	11	20.75
Both	4	7.55
Importance of use of PPEs in reducing exposures		
Yes	101	98.06
No	2	1.94
Hindrances to the usage of PPEs		
Cost	56	70.89
Uncomfortability	13	16.46
Does not offer any protection	3	3.80
Availability	6	7.59
Do not know how to use them	1	1.27
What is done when affected by welding fumes		
I don't do anything	21	20.39
I only take some rest and continue	26	25.24
I buy medicine from the drug store	43	41.75
I go to the hospital for treatment	10	9.71
I don't get affected with the fume	1	0.97
I take a drink and continue	2	1.94
Medical check up		
I don't go at all	58	56
Only when I'm sick	29	28.4
Every 6months	7	6.86
Once a Year	5	4.9
2 years and above	3	2.94

4.8 Other Personal Protective Equipment used by welders

From figure 5, welding goggles were the most used personal protective equipment recording 24.3% followed by safety boots recording 23.8%. The least used protective equipment is welding screen/shield.

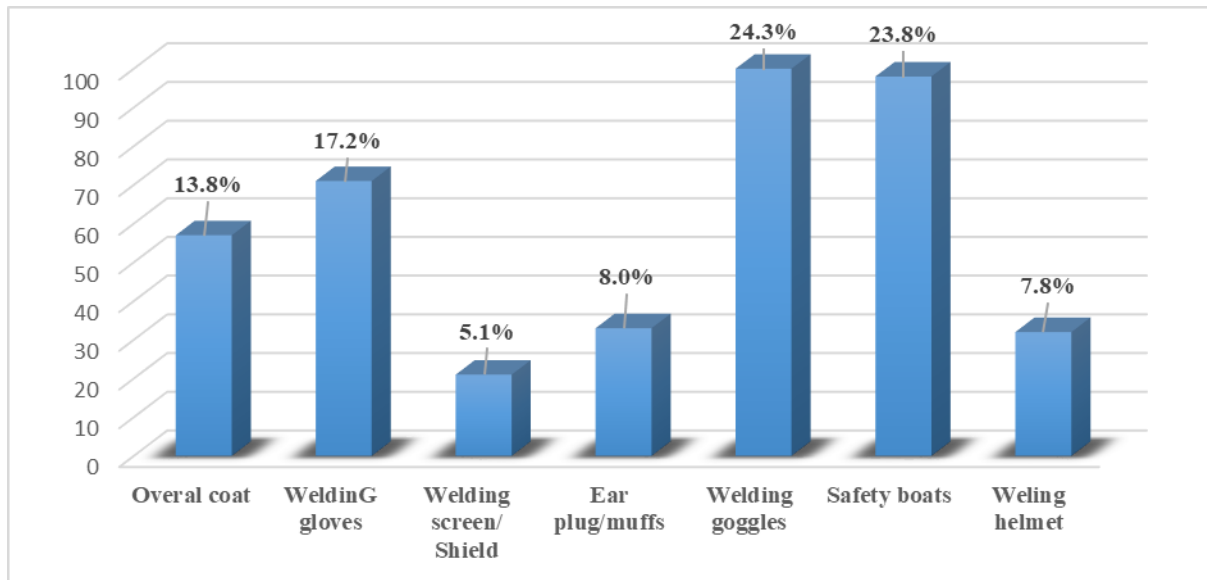


Figure 5: Other Personal Protective Equipment used by welders

4.8.1: Association of Safety measures used by welders to reduce exposure to welding fumes with lung function.

Table 9, presents information on chi-square test investigating the association between Safety measures used by welders to reduce exposure to welding fumes with lung function. The results indicated that Hindrances to the usage of PPEs ($p=0.01<0.05$) is significantly associated with lung function. However, being trained on use of PPEs, use of respiratory protective equipments, and specification of respiratory protective equipment and importance of PPEs use were not statistically associated with lung function.

Table 9: Association of Safety measures used by welders to reduce exposure to welding fumes with lung function.

Characteristics	Low	Normal	χ^2	P-value
Trained on use of PPEs				
Yes	4 (6.25)	60 (93.75)	0.71	0.65
No	1 (2.56)	38 (97.44)		
Use Respiratory Protective Equipment				
Yes	2 (4.65)	41 (95.35)	0.51	1.00
No	3 (5.77)	49 (94.23)		
Sometimes	0 (0.00)	8 (100.00)		
Type of Respiratory Protective Equipments				
Face mask	0 (0.00)	38 (100.00)	7.94	0.08
Respirators	2 (18.18)	9 (81.82)		
Both	0 (0.00)	4 (100.00)		
Importance of use of PPEs in reducing exposures				
Yes	5 (4.95)	96 (95.05)	0.10	1.00
No	0 (0.00)	2 (100.00)		
Hindrances to the usage of PPEs				
Cost	2 (3.57)	54 (96.43)	21.17	0.01
Uncomfortability	0 (0.00)	13 (100.00)		
Does no offer any protection	0 (0.00)	3 (100.00)		
Availability	3 (50.00)	3 (50.00)		
do not know how to use them	0 (0.00)	1 (100.00)		

Note: P-value = Fisher's exact, χ^2 =chi-square

4.9 Assessment of lung function of welders

From the table 10 below, respondents were asked how often they had experienced any of the following respiratory symptoms after welding, throat irritation, cough, wheezing and difficulty in breathing.

For throat irritation, (1.94%) always experienced it, (28.16%) sometimes had it and (69.9%) did not have it at all. With cough, (4.85%) always have cough, (66.02%) sometimes have it and (39.13%) do not have it at all. (1.94%) always experienced difficulty in breathing, (36.89%) sometimes had difficulty in breathing and (61.17%) did not have that problem at all. (8.74%) sometimes experience wheezing while (91.26%) never experience wheezing. 1.94% of respondents, sometimes had bloody cough whereas (98.06%) had never coughed blood. (2.91%) were currently on respiratory medications while (97.09%) were not respiratory medication. (66.99%) respondents had ever been absent from work due the respiratory symptoms above and (33.01%) had never been absent from work due to any of the respiratory symptoms. Also (39.89%) has ever visited hospital due to respiratory symptoms whereas (60.19%) had never visited the hospital. Among the respondents, (81.55%) never smoked, (6.8%) were former smokers and (11.65%) were currently smoking.

Table 10: Assessment of lung function of welders

Characteristics	Frequency	Percentage (%)
Throat irritation		
Always	2	1.94
Sometimes	29	28.16
Not at all	72	69.90
Cough		
Always	5	4.85
Sometimes	68	66.02
Not at all	30	29.13
Difficulty in breathing		
Always	2	1.94
Sometimes	38	36.89
Not at all	63	61.17
Wheezing		
Sometimes	9	8.74
Not at all	94	91.26
Coughed blood		
Sometimes	2	1.94
Not at all	101	98.06
Surgery		
Yes	3	2.91
No	100	97.09
Currently on respiratory medication		
Yes	3	2.91
No	100	97.09
Absentism from work due to symptoms		
Yes	69	66.99
No	34	33.01
Visited hospital due to symptoms		
Yes	41	39.81
No	62	60.19
Smoking		
Never	84	81.55
Former	7	6.8
Current	12	11.65

4.9.1 Association of smoking and lung function

Table 11 presents information on chi-square test investigating the association between smoking and lung function outcome. The results indicated that smoking was not statistically significantly associated with lung function.

Table 11: Association of smoking and lung function

Characteristics	Low	Normal	χ^2	P-value
Smoking				
Never	4 (80.00)	80 (80.63)	1.96	0.38
Former	1 (20.00)	6 (6.12)		
Current	0 (0.00)	12 (12.24)		

Note: P-value = Fisher's exact, χ^2 =chi-square

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This section caters for discussion of results presented in chapter four in comparison with related literature reviewed. Discussion is done according to the objectives of the study.

5.2 Demographic characteristics of respondents

Majority (24.75%) of welders were in the age category of 18-24 years, similar to findings of Kumah et al., (2011) but differs from findings of Adu, (2011) where the majority 100 (50%) in the same country were aged between 31-49 years. Majority of respondents were predominantly males as in the case of (Budhathoki et al., 2014; Kumah et al., 2011). The findings of this study reported more singles (66.02%) than married which is a reverse of all other studies perhaps this is due to the fact that majority were younger and still under apprenticeship. Also most of the welders had had some form of basic education (80.56%) whereas (13.59%) had senior high school education and (2.91%) has no form of formal education. This should be an influencing factor on their level of knowledge. This results agree with the findings of (Amfo-Otu & Agyemang, 2016) who reported that about (85.7%) of auto mechanics including welders in Ghana had had some basic form of formal education. It is however in contradiction to that of (Sabitu, Iliyasu, & Dauda, 2009) whose findings revealed (62.7%) secondary education among welders in Kaduna Metropolis in Nigeria. Again almost all the welders acquired their training through apprenticeship (93.20%) similar to findings of Adu, (2011). This could probably be due to financial constraints as most parents will have to spend a lot of money to cater for second cycle institutions as well as tertiary. On the issue of sector, current findings corroborate with that

of (Tijani, Fwacn et al., 2014) which revealed that most welders spent years acquiring training from informal sectors rather than formal.

5.3 Knowledge of welders on respiratory effect of welding fumes

Majority of the respondents were knowledgeable about the respiratory effects of welding fumes whereas only (3.88%) had average knowledge on the respiratory effects of welding fumes however it was realized that education played a role. This is in line with the study conducted by (Budhathoki, Singh, Sagtani, Niraula, & Pokharel, (2014) which unearthed that majority of welders 90% were aware of at least one hazard associated with welding. Again, it was also realized that education and duration of employment played significant roles. In Ghana, the prevalence is similar to that of Arts & Nadu,(2010) who revealed that out of the 330 participants, (77.9%) of them were aware of one or more occupational hazards associated with welding however it was influenced by educational level, training and work experience. Also most of the respondents (83.50%) were in support of the fact that prolong exposure to welding fumes could affect their lungs, this however disagrees with the results of (Das, 2015) proving that about (72%) of welders were reluctant to accept the consequences of prolong exposure to welding fumes on their health.

The results show that respondents' level of knowledge had no significant influence on the use of PPE ($p > 0.05$). Results of this study is in agreement with that of (Jessy, 2015) whose study showed that majority of welders (98%) were knowledgeable of at least one welding related hazard. Findings of (Rasaq ADEWOYE et al., 2013) showed that (64.9%) had poor knowledge regarding welding smoke effects which accounted for the significant association between knowledge and use of face mask.

5.4 The Effects of Welding Fumes on Lung Function of Welders

Findings from this research showed that majority (95.15%) of welders had normal lung function outcomes while five (5.85%) had low lung function outcomes. Out of which two (3.34%) were females and three (3.51%) were males. There was a significant association between sex and lung function outcome however no studies have been able to prove. In agreement to (Antonini, 2003), chronic effects of exposure to the variety of welding elements can take the form of many serious illnesses including Chronic Obstructive Pulmonary Disease (COPD), however prolonged duration of exposure plays a role.

Even though most of welders complained of some respiratory symptoms, these symptoms were however not statistically significant. Findings of this study is similar to a study conducted by (AlOtaibi, 2014) in Saudi Arabia which revealed that, prevalence of respiratory symptoms and chronic bronchitis was on the increase among welders compared to non-exposed however there was no lung function impairment. Even though smoking is known to be a predisposing factor for respiratory disorders, only (11.65%) were currently smoking whereas (6.8%) were former smokers, the rest of the respondents had never smoked. The differences were statistically insignificant, (Fisher's exact test, $P=0.383$). After confounding for smoking, the difference were statistically insignificant (χ^2 , $P = 0.1203$), (Al- Otaibi, 2014).

Lung function outcomes after spirometry in welders revealed normal outcomes among the greater population as working period was statistically insignificant (Fisher's Exact $P>0.270$). However, two studies conducted in Iran (Golbabaie et al., 2013) and (Sharifian et al., 2010) disprove the current results such that, lower pulmonary function levels after spirometry in

welders indicated that welders were more susceptible to pulmonary diseases after investigating for the effects of welding fumes on the lungs and respiratory symptoms as well as decrease in pulmonary function of welders was associated with welding

However a prospective study conducted by (Christensen et al., 2008) revealed that decline in lung function of welders was not related to the cumulated welding particulate exposure during follow-up period and this supports our current findings.

5.5 Factors and practices that expose welders to welding fumes.

Location of welding workshops was an important variable in determining lung function outcome however results showed that (84.47%) workshops were located in open places with natural source of light and ventilation. This was a good practice since it helped in reduction of fumes inhalation hence accounted for the reason why there were no Local Exhaust Ventilation (LEV) in the workshops. This is also similar to findings of a research conducted in Lusaka by (Jessy, 2015) who observed that most of the welding workshops were also situated in open places with natural illumination. However there was no significant association ($p > 0.578$) between welding in confined space and low lung function outcome. According to (Health & Commission, 1990) LEV was not effective in influencing ozone due to formation of gas away from arc. To disprove this, recent review of literature by (Flynn & Susi, 2012) disclosed that LEV can decrease exposure to welding fumes below acceptable levels.

The normal working hours for the greater number respondents (84.47%) was between nine to twelve hours. This indicates that they were at more risk of exposure to hazards. This concurs to the findings of (Amfo-Otu & Agyemang, 2016) conducted in Ghana among informal auto mechanics showed that about (75%) respondents worked for more than eight hours per day. In

addition, present results show most welders (59.22%) had less than six years work experience hence short duration of exposure to welding fumes thereby accounting for the greater percentage (95.15%) in normal lung function outcome however prevalence was not statistically significant ($p>0.05$).

Findings of (Kumah et al., 2011) are in contrasts as it was presented that more than two-thirds of welders had more than six years work experience with the majority (51.5%) having worked for more than ten years and so observed prevalence to ocular conditions was statistically significant ($p<0.05$). A greater percentage (81.55%) were involved in the Electric/Arc welding process which automatically influenced their selection of welding electrode thus consumable electrode (83.50%) being greatly used, which corroborate with the findings of (Antonini, Taylor, Zimmer, & Roberts, 2004) also unveiling that arc welding was a most common type of welding process. Majority of welders were found using stainless steel for their work, others also used galvanize, which produces fumes found to possess carcinogenic properties due to presence of chromium and nickel (Baldwin et al., 2004; Health & Commission, 1990; Sjogren et al., 1994).

5.6 Safety measures used by welders to reduce exposure to welding fumes

A greater number of welders (62.14%) had gone through a form of Personal Protective Equipment training and (98.06%) acknowledged the importance of the use of PPEs. Unlike a research conducted, by (Amfo-Otu & Agyemang, 2016) in Ghana, results showed that most auto mechanics of which welders were part did not realize the essence of using PPEs for their own safety. However, only (41.75%) always used and (7.77%) sometimes respiratory protective devices. Current result is similar to that of (Rasaq ADEWOYE et al., 2013) of which (34.8%) always used face mask whereas (21.7%) used facemask occasionally. Other PPEs used by

welders included welding goggles (24.3%), safety boots (23.8%), welding gloves (17.2%), overall coat (13.8%) however it was found that most welders used at least more than one of the other PPE during welding. This concurs well with studies on welders in Zambia and Nigeria in which majority of welders used at least one or types of PPEs of (Jessy, 2015; Budhathoki et al., 2014). The results indicated that, hindrances to the usage of PPEs ($p=0.013<0.05$) is significantly associated with lung function. Most welders (70.89%) complained of the cost involved in purchasing the PPEs as well as its uncomfotability (16.46%) however few (3.8%) of them also said PPEs did not offer any form of protection. Concerning the health seeking behaviours of welders, it was observed that majority of respondents (41.75%) resorted to the use of Over-the-counter drugs when affected by the welding fumes and only (97%) went to hospital for treatment which was not encouraging.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Introduction

This is the final chapter and it composes of conclusion of the study, recommendation and limitations of the study as well as areas for future concentration.

6.2 Conclusion

This study sought to assess the effects of welding fumes on lung function of welders in the Birim North District. In conclusion, it was found that, though majority (95.15%) of welders had normal lung outcomes, some cases of low lung function outcomes were also recorded among five (4.85%) participants of which three were males and two were females. However, this was not influenced by factors and practices associated with welding fume exposure. Also smoking ($P=0.38$) had no significant influence on lung function outcome but sex was statistically significant ($p=0.01$) therefore needs to be further researched into.

Again, majority of the welders were young with few years (1-5 years) of work experience and had had short duration of exposure to welding fumes. Location of workshops played positive role as most workshops were located in open places with adequate ventilation hence the probability of getting exposed was low. Majority of welders were knowledgeable of the health effects of welding fumes on the lungs therefore, acknowledged the importance of the use of PPEs and used at least one form of PPEs especially goggles, however utilization of PPEs was not in full effectiveness as this was influenced by certain hindrances such as cost and availability hence ($p=0.01 < 0.05$) was significantly associated with lung function outcome. Concerning the

health seeking behaviors of welders, it was observed to be poor such that a greater population of welders had never sought for any form of medical attention but however resorted to the use of over-the-counter drugs for treatment of welding symptoms. Furthermore, majority of welders were found using stainless steel and galvanized for their work though not statistically significant in this study, but produces fumes found to possess carcinogenic properties, therefore much importance should be placed on long-term exposure to welding fumes.

6.3 Study limitations

This study conducted was a cross-sectional study which places limits on it therefore, a prospective study will be beneficial to better clarify the nature of associations. Also there was no baseline to which current lung function outcomes could be compared to.

6.4 Recommendation

The following recommendations are made following the findings of this research to the various stakeholders.

6.4.1 Government/Policy Makers

1. Government should set up a regulatory body to oversee and monitor the activities of welders and other automechanics in the informal sector.
2. It was observed that majority of the welders were ignorant of the constituents of materials they used during welding including the threats they posed. It is therefore recommended that, welders should be well educated on the chemical composition of the various materials used as well as the hazards associated with them.

3. Government should enforce the use of personal protective equipments among welders and other automechanics in the informal sector.
4. Due to the poor health seeking behavior of welders, policies that address the health need of welders should be ensured including the implementation of periodic medical examination and issuing certificates.

6.4.2 Employers/Masters

Employers/masters should ensure availability of required personal protective equipments for their employees and apprentices as well as ensure their effective utilization.

6.5 Further Research Areas

The following areas have been recommended for further research based on findings of this study:

- Factors accounting for the decrease lung function outcome among female compared to males.
- Health related quality of life of welders.

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APPENDICES

Appendix 1 Informed consent form

SCHOOL OF PUBLIC HEALTH-UNIVERSITY OF GHANA-LEGON

WELDING FUMES AND ASSOCIATED LUNG FUNCTION OUTCOMES AMONG WELDERS IN THE BIRIM NORTH DISTRICT

Dear Respondent,

My name is **MERCY NYARKOAH ANARFI** and I am student at the School of Public Health, university of Ghana, Legon. I am conducting a research on the topic: Welding Fumes and associated Lung Function outcome among Welders in the Birim North District. As part of the study I would be very grateful of you could support this effort by giving 30 – 45 minutes of your time by completing the questionnaire below and also partake in a lung function test (spirometry) following this process; Height, weight and blood pressure will be measured and filled on the form after which the participant will be made to stand at ease and loosen any tight clothing such as belt and tie. Participant will insert the Mouth piece of the spirometer into the mouth with lips sealed around it and nose held to prevent air from escaping. Participant will be asked to take in a quick deep breath and blow out hard and fast. Participant will be asked to breathe in again through the mouth and remove the mouth piece from your mouth and relax. Complete test series will consist of 3 – 8 blows. Participants will need at least 3 blows within the acceptable limits with 2 repeatable tests. If you are unable to get 3 acceptable blows, the subject will be made to blow up to 8 times. Once the test is completed it will be printed out for participant to sign. After 8 blows, subject will be allowed to rest for 10 minutes and try again. Participant will be asked to stop and rest in case he feels exerted. The results will be interpreted to participants and advised

accordingly and thanked for their cooperation. The information from test results will be used to educate welders to take precautionary measure to prevent hazards associated with welding as well as assisting those with respiratory and lung disorders to seek early medical attention.

Please note that participation is voluntary and one can choose to withdraw at any time. Also refusal to be part will not attract any fine, loss or penalty. There are no rights or wrong answers to the statements so honesty in your response is necessary. Your name will not be indicated on the questionnaire. This exercise is for academic purpose only and as such all response shall be confidential and used for intended purpose only. During the lung function test, screen will be provided to ensure privacy whereas test results will be communicated to participants individually. Participants will not receive any compensation from this study however, participants will be provided with snacks after the test.

Also further clarification can be sought from the Administrator of Ghana Health Service Ethical Review Board (Hannah Frimpong 0507041223) when needed.

Please indicate your acceptance by signing.

Signature / thumbprint Thank you for co-operating.

Kindly contact Mercy Nyarkoah Anarfi for any further explanation on **0249383167/0269245355**
nyakoahwadie@gmail.com

PARTICIPANT CONSENT

I have been given adequate information on the purpose, procedure and risk and benefits of this study. I have had the opportunity to ask questions and have been given the answers to my satisfaction. I know that I can refuse to participate without any penalty. I also understand that information collected will be treated confidential and used for intended purpose only. Finally, findings may be used in assisting welders to take precautionary measure to prevent hazards.

Appendix 2: Questionnaire

SECTION A. DEMOGRAPHIC DATA

Please tick all that apply in the Brackets (√) provided.			
1	Gender of welder	1. Male ()	2. Female ()
2	Height in (cm)		
3	Weight (kg)		
4	Age at last birthday		
5	Marital Status	1. Single ()	2. Married ()
		3. Divorced ()	4. Widowed ()
6	Level of Education	1. None ()	2. Primary ()
		3. JHS ()	4. SHS ()
		5. Technical/Vocational ()	6. Tertiary ()
7	How did you become a welder?	1. Though Apprenticeship ()	
		2. Technical/ Vocational ()	
		3. Tertiary education ()	
8	Level of Income per month	1. >GHS 500 ()	
		2. GHS 500-1000 ()	
		3. GHS 1,001-2,000 ()	
		4. Above GHS 2,000 ()	
9	What is your position?	1. Master ()	2. Supervisor ()
		3. Employee/Worker ()	4. Apprentice ()
10	Where do you work?	1. Industry/ Formal ()	2. Private/Informal ()

SECTION B: KNOWLEDGE ON THE EFFECTS OF FUMES ON THE LUNGS

<i>Please tick all that apply in the Brackets (✓) provided.</i>					
11	What do you think can cause harm to your respiratory system in your welding work?	1.Welding fumes ()		2.Others	
12	Do you produce welding fumes during welding?	1. Yes ()		2. No ()	
		Strongly Disagree	Disagree	Agree	Strongly Agree
13	Do you think the welding fumes can affect your health?	1.()	2. ()	3. ()	4. ()
14	Can welding in confined space expose you more to welding fumes?	1.()	2. ()	3. ()	4. ()
15	Can <u>prolonged</u> exposure to welding fumes affect your lungs?	1.()	2. ()	3. ()	4. ()
16	Do you think not protecting your nose/mouth can make you breath in welding fumes which will cause more harm to your lungs?	1.()	2. ()	3. ()	4. ()
17	Do you think welding fumes can make you experience these symptoms? (cough, difficulty in breathing, cold, wheezing)	1.()	2. ()	3. ()	4. ()

KNOWLEDGE	SCORES	
Excellent	20-16	
Good	15-12	
Average	11-9	
Weak	8-5	
Poor	<4	

SECTION C: FACTORS AND PRACTICES THAT EXPOSE WELDERS TO WELDING

FUMES

<i>Please tick all that apply in the Brackets (√) provided.</i>					
18	Location of work shop?	1. Confined space ()		2. Open place ()	
19	How long have you been working as a welder?	1. Less than 1 year ()		2. 1-5years ()	
		3. 6-10 Years ()		4. 10-20 years ()	
		5. Above 20 years			
20	What is your normal working hours in a day?	1. Less than 6 hours	2. 6-8 hours	3. 9-12 hours	
21	What type of welding do you do?	1. Electric / Arc welding ()	2. Gas welding ()	3. Both ()	
22	How much time do you spend on welding a day?	1. <hour ()	2. 1-3hrs ()	3. 4-6hrs ()	4. >7hours ()
23	Which type of electrode do you use	1. Consumable electrode ()	2. Non-consumable electrode ()	3. Both ()	
24	What materials do you normally use during welding?	1. Aluminium ()		2. Carbon ()	
		3. Lead ()		4. Cobalt ()	
		5. Iron ()		6. Copper ()	
		7. Manganese ()		8. Stainless steel ()	
		9. Others			
26	Do you have a local exhaust ventilation at the work shop?	1. Yes ()		2. No ()	

SECTION D: SAFETY MEASURES USED BY WELDERS TO REDUCE EXPOSURE TO WELDING FUMES.

<i>Please tick all that apply in the Brackets (✓) provided.</i>			
27	Have you ever had any training on the use of PPEs?	1. Yes ()	2. No ()
28	Do you use anything to cover your nose/mouth to help you breath well during welding?	1. Yes ()	2. No () 3.Sometimes ()
29	IF YES specify	1. Face mask () 2. Respirators () Others specify	
30	Do you think the use of PPEs is important in reducing exposure?	1. Yes ()	2. No ()
31	What other protective equipment do you use to protect yourself during welding	1. Overall coat	2. Welding gloves
		3. Welding screens /shield	4. Ear plugs/muffs
		5. Welding goggles	6. Welding helmet
		7. Safety boots	8. Others specify
32	How often do you use the protection above at work?	1. Not at all ()	2.Occasional() 3. Always ()
			1. Yes 2. No
33	Is there anything that prevents you from using PPEs? <i>(ask an open ended question an tick what applies)</i>	Cost (affordability)	1. () 2. ()
		Uncomfortable	1. () 2. ()
		It does not offer any protection	1. () 2. ()
		Availability	1. () 2. ()
		Do not know how to use them	1. () 2. ()

34	What do you do when you are affected by the welding fumes?	1. I don't do anything ()
		2. I only take some rest and continue ()
		3. I buy medicine from the drug store ()
		4. I go to the hospital for treatment ()
35	How often do you go for medical check up	1. I don't go at all ()
		2. Only when I'm sick ()
		3. Every 6months ()
		4. Once a Year ()
		5. 2 years and above ()

SECTION E: ASSESSMENT OF LUNG FUNCTION OF WELDERS USING THE SPIROMETER

Please tick all that applies in the Brackets (√) provided.

	Have you ever experienced any of the following respiratory symptoms after welding before And how often? <u>(please tick all that apply) or</u>	Always	Sometimes	Not at all
36	Throat irritation	1. <input type="checkbox"/>	2. <input type="checkbox"/>	3. <input type="checkbox"/>
37	Cough	1. <input type="checkbox"/>	2. <input type="checkbox"/>	3. <input type="checkbox"/>
38	Difficulty breathing?	1. <input type="checkbox"/>	2. <input type="checkbox"/>	3. <input type="checkbox"/>
39	Wheezing	1. <input type="checkbox"/>	2. <input type="checkbox"/>	3. <input type="checkbox"/>
40	Have you ever coughed blood since you became a welder?	1. <input type="checkbox"/>	2. <input type="checkbox"/>	3. <input type="checkbox"/>
41	Have you had any surgery in the last month? If yes specify type time and date	1. Yes <input type="checkbox"/>	2. No <input type="checkbox"/>	
42	Are you taking any medication now for respiratory illness?	1. yes <input type="checkbox"/>	2. No <input type="checkbox"/>	
43	Do you have asthma? If you are asthmatic, when did you last use your ventolin? (date and time)	1. Yes <input type="checkbox"/> 2. No <input type="checkbox"/>		

44	Did you ever have to be absent from work due to any of these symptoms mentioned above?	1. Yes () 2. No ()						
45	Have you ever visited a hospital because of these symptoms?	1. Yes () 2. No ()						
46	Do you smoke?	<table border="0"> <tr> <td>Never</td> <td>Former</td> <td>Current</td> </tr> <tr> <td>1. ()</td> <td>2. ()</td> <td>3. ()</td> </tr> </table>	Never	Former	Current	1. ()	2. ()	3. ()
Never	Former	Current						
1. ()	2. ()	3. ()						
47	Blood Pressure							
48	FEV1	80% or above Normal						
		79-70% mildly abnormal						
		69-60% Moderately abnormal						
		59-50% Moderately-severely abnormal						
		49-35% severely abnormal						
		>35% very severely abnormal						
		<table border="0"> <tr> <td>Normal</td> </tr> <tr> <td>Abnormal</td> </tr> </table>	Normal	Abnormal				
Normal								
Abnormal								
49	FVC	80% or Above less than 80%						
50	FEV1/FVC	70% or Above less than 70%						

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

1. _____
2.