

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

**MAPPING OF HEALTH CONDITIONS ASSOCIATED WITH E-WASTE
ACTIVITIES AT AGBOGBLOSHIE, ACCRA**



**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF GHANA,
LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE
AWARD OF MSc OCCUPATIONAL HYGIENE DEGREE**

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DECLARATION

I, Abenaa Antwiwaa Adusei, declare that except for the other people’s investigations which have been duly acknowledged, this work is the result of my own original research, and that this dissertation, either in whole or in part has not been presented elsewhere for another degree.

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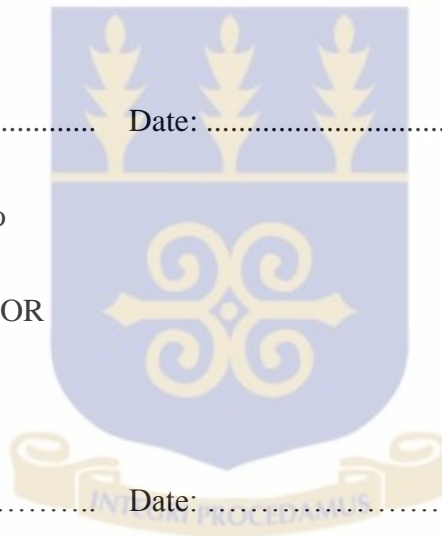
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DEDICATION

I dedicate this piece to my dearest husband, Samuel Adusei for being the most amazing husband any schooling wife will ever wish for and to my precious boys, Barima Kofi Gyamfi Adusei and Kwame Poku Adusei for being there for me anytime I needed them. For all the moments I could not share with you because of this work, I owe you this piece.



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ABSTRACT

E-waste, known also as electronic or electrical waste, is a term used to describe discarded electronic devices which use either electricity or battery for operation. These include, computers, televisions, mobile phones, printers and many more.

Background: E-waste activities include the collection of discarded e-waste materials from various locations. These are then brought to the e-waste site for sorting, dismantling and open burning to extract the precious elements. The activities of the e-waste workers expose them to health hazards such as injuries and skin conditions.

Objectives: The objective of this study was to conduct a spatial assessment and analysis of health conditions associated with different e-waste activities at different activity spaces at Agbogbloshie.

Methods: A total of one hundred and twelve (112) subjects were conveniently sampled from the activity spaces. The various health outcomes of interest were assessed using direct physical examination and the administration of open and close ended questionnaires.

Results: A map showing the various activity spaces at the Agbogbloshie e-waste site was generated using Eteri GPS device. Findings showed that a total of 96.2% of all the study subjects had cuts and the dismantlers had a higher percentage amongst them all. Among the injuries, the prevalence of abrasion was 16.3% with a p-value of 0.038. This was statistically significant between the different activity groups. Scars were the most common skin condition. Prevalence of burns among the study subjects was 23.1% and with a p-value of 0.000, it could be said there was a significant association of sustaining burns with activity space. There was no significant difference in being hypertensive across all activity spaces. There were a total of 90.2% normotensive and 9.8% hypertensives among study

subjects. 98.2% of respondents felt the need to have a first aid clinic at the site with 96.4% and 97.3% being willing to visit the clinic and pay for services respectively.

Conclusion and Recommendations: Education of workers on the effective use of personal protective equipments, the use of modern equipments to disassemble e-waste materials and provision of alternatives to open burning of e-waste will help reduce the prevalence of injuries and skin conditions. First aid clinic at the site will be such a welcoming news for the workers.

TABLE OF CONTENTS

Content	Page
DECLARATION.....	i
DEDICATION.....	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
TABLE OF CONTENTS.....	vi
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATIONS	xi
DEFINITION OF TERMS:	xii
CHAPTER ONE	1
INTRODUCTION.....	1
1.1 Background of the Study	1
1.2 Statement of the Problem	5
1.3 Objectives	6
1.3.1 General objectives:	6
1.3.2 Specific Objectives:	6
1.4 Hypothesis:	7
1.5 Conceptual framework	7
1.6 Justification.....	8
1.7 Limitations of the Study	9
CHAPTER TWO	10
LITERATURE REVIEW.....	10
2.1 Overview	10
2.2 Definition of E-waste	10
2.3 Collection of E-Waste Materials.....	12

2.4 Sorting of E-Waste Materials	13
2.5 Dismantling of E-Waste Materials.....	13
2.6 Burning of E-Waste Materials	14
2.7 Health Conditions Associated With E-Waste Activities.....	16
2.7.1 Skin Conditions	16
2.7.2 Injuries	18
2.7.3 High Blood Pressure	19
2.8 Health seeking behaviour and the need for an on-site first aid clinic	21
CHAPTER THREE	24
METHODS	24
3.1 Overview	24
3.2 Type of Study Design.....	24
3.3 Study Location/Area	24
3.4 E-waste processing and recycling.....	24
3.5 Study Population	26
3.6 Variables.....	26
3.6.1 Dependent variables (outcome variables):	26
3.6.2 Independent variables:	26
3.7 Sample Size	27
3.8 Sampling Method.....	27
3.8.1 Inclusion Criteria	27
3.8.2 Exclusion criteria.....	28
3.9 Data Collection Techniques.....	28
3.10 Data Collection and tools	29
3.11 Quality Control	29
3.12 Data Processing and Analysis.....	30
3.13 Ethical Consideration	30

3.14 Pre-test/Pilot Study.....	31
CHAPTER FOUR.....	32
RESULTS	32
4.1 Overview	32
4.2 Mapping of different e-waste processing activities	32
4.3 Demographic Characteristics of the Study Participants	35
4.4 Prevalence of injuries at activity spaces.....	36
4.5 Prevalence of skin conditions at activity spaces	37
4.6 Common injuries with background characteristics	38
4.7 Skin conditions with background characteristics.....	39
4.8 Assessment of Systolic and Diastolic Blood Pressure	40
4.9 Health seeking behaviour and the desire of e-waste workers for a clinic at the dump site.....	41
4.10 Use of Personal Protective Equipments (PPE)	43
CHAPTER FIVE.....	46
DISCUSSION	46
5.1 Overview	46
CHAPTER SIX	55
CONCLUSIONS AND RECOMMENDATIONS.....	55
6.1 Conclusions	55
6.2 Recommendations.....	56
REFERENCES.....	58
APPENDICES	64
Appendix 1: Consent Form	64
APPENDIX 2: STUDY INSTRUMENTS.....	67

LIST OF TABLES

Table 4.1: Table showing generated coordinates.....	33
Table 4.2: Demographic characteristics of study subjects.....	35
Table 4.3: Assessment of injuries with activity space.....	36
Table 4.4: Assessment of skin conditions at activity space.....	38
Table 4.5: Injuries with background characteristics.....	39
Table 4.6: Skin conditions with background characteristics	40
Table 4.7: Mean systolic and diastolic blood pressure across activity spaces.....	41
Table 4.8: Blood pressure with age categories.....	41
Table 4.9: Health seeking behaviour and knowledge NHIS.....	42
Table 4.10: Personal Protective Equipment use and type by activity space.....	44
Table 4.11: Personal Protective Equipment use and years of work or daily working hours	44
Table 4.12: Personal Protective Equipment use among age categories	45
Table for recording blood pressure readings.....	76

LIST OF FIGURES

Figure 1: The WEEE man (source: Paul Bonomini, Eden Project (2011)	1
Figure 2: Conceptual framework.....	8
Figure 3: GPS-generated map showing different e-waste processing activities at Agbogbloshie	33
Figure 4: Need for a First Aid Clinic.....	42
Figure 5: Willingness to attend the first aid clinic	43
Figure 6: Willingness to pay for health care services.....	43

LIST OF ABBREVIATIONS

ATSDR	-	Agency for Toxic Substances and Disease Registry
BP	-	Blood Pressure
CRT	-	Cathode Ray Tube
Cu	-	Copper
DBP	-	Diastolic Blood Pressure
EEE	-	Electrical and Electronic Equipment
ETRI	-	Electronics and Telecommunications Research Institute
EW	-	E-waste Workers
GPS	-	Global Positioning System
HBP	-	High Blood Pressure
ILO	-	International Labour Organization
KKPKP	-	Kagad Kach Patra Kashtakari Panchayat
LCD	-	Liquid Crystal Display
MeHg	-	Methyl mercury
Pb	-	Lead
PPE	-	Personal Protective Equipment
SBP	-	Systolic Blood Pressure
WEEE	-	Waste Electrical and Electronic Equipment
WHO	-	World Health Organization
MRTAB	-	Multiple Response Tabulation
SWaCH	-	Solid Waste Collection and Handling

DEFINITION OF TERMS:

1. **Abrasion**- scratch leading to tearing of the skin
2. **Activity area or space**- a place or zone within the e-waste site where a specific e-waste activity takes place.
3. **Agbogbloshie**- an e-waste processing site in Accra, Ghana.
4. **Avulsions**- a forcible tearing or separation of one body part from another.
5. **Basel Convention**- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal; adopted in 1989 and entered into force in 1992.
6. **Burns**- injuries caused by exposure to heat or chemicals.
7. **Cuts**- to sever; to make an incision
8. **Dermatitis**- inflammation of the skin.
9. **E-waste**- a term used to describe discarded electronic devices which use either electricity or battery to operate.
10. **Electronic waste**- another term for e-waste and definition is same for e-waste
11. **E-waste worker**- any person who engages in the e - waste activity.
12. **High blood pressure**- a chronic medical condition in which the blood pressure in the arteries is increased. If it is checked and reading is 140/90mmHg or more for three consecutive times.
13. **Hypertension** – a disorder in which blood pressure remains abnormally high (a reading of a 40/90 mmHg or greater
14. **Hypertensive** – a person who has abnormally high blood pressure
15. **Laceration**- a torn ragged wound.
16. **Normotension** – blood pressure that is within the normal range

17. **Normotensive** - a person who has normal blood pressure
18. **Mapping**- creating a graphic representation of information using spatial relationships within the graphic to represent some relationships within the data.
19. **Rashes**- fine eruptions on the body with little or no elevation.
20. **Scars**- a mark left by the healing of injured tissue.
21. **Scavengers**- e-waste workers involved in the collection of e-waste materials from various sources.
22. **Skin allergies**- hypersensitivity reaction of the skin to a particular allergen.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The United Nations Environment Programme, UNEP (2005) estimates that between 20 and 50 million tons of e-waste are generated worldwide annually, accounting for about 5% of all municipal solid waste. Not only is the figure representing the fastest growing municipal waste stream, it also has the potential of increasing further. For example, in the case of mobile phones, 98 million phones are said to be discarded in America annually (Oteng-Ababio, 2012). Illustrating the amount of Waste Electrical and Electronic Equipments (WEEE) that are discarded by the average British household in a lifetime, an artist, Paul Bonomini, came out with a sculpture that has come to be called the WEEE man (figure 1). His bones and sinews are made up of mp3 players, mobile phones, lawn mowers and the like whereas his teeth have been built with computer mice. Satellite dishes and computer parts make up the ears and brain, respectively (Eden project, Bonomini, 2011).



Figure 1: The WEEE man (source: Paul Bonomini, Eden Project (2011))

In general, electronic gadgets are meant to make our lives easier and simpler, but because of the toxic chemical they contain, their disposal and recycling become a health nightmare. Most of the users are unaware of the potential negative impact of rapidly increasing use of computers, monitors, and television (Needhidasan et al., 2014).

However, there is limited recycling technology for e-waste disposal and safe management especially in the developing countries where most of the wastes end up, although large quantities of the e-wastes are generated in the developed world. For example, in her work “High Tech Trash, Digital Devices, Hidden Toxins, and Human Health”, Elizabeth Grossman states that “the United States discards enough electronic waste annually to cover a football field, a mile high and that of this waste, only 10% is recycled for materials recovery” (Grossman, 2006). Most of the electronic wastes go to landfills or waste incinerators. Electronic devices which were in high demand yesterday all too soon have to go and make way for newer models today. As a result, there is a piling of slightly used, unused and broken-down devices. The burden then becomes getting rid of these devices which are no more in use because going through the right means to get rid of them could be very expensive as these developed countries have stringent measures when it comes to e-waste disposal. As a result, most of these find their way to developing countries as second-hand goods where there is greater need for electronic devices to keep pace with modern electronic trends and information communication technology. These enter the countries under the guise of donations, being sold to importers at a very cheap price or being illegally imported into the country. In Ghana, most of these end up at the Agbogbloshie e-waste site.

Before the arrival of electronic waste, Agbogbloshie was a wetland known as Old Fadama. It was the place of escape for refugees running from the Kokomba and Nanumba (located in the Northern part of Ghana) war (NewsBeeakingonline.com, 2011). The Agbogbloshie

area is less than one kilometre from the Central Business District of Accra and is about thirty-one hectares in size (Oteng-Ababio, 2012). It is bounded south, west and Northwest by the Odaw River, which feeds into the Korle Lagoon. There is a popular yam and onion wholesale market close to the e-waste site. In totality, the scrap yard takes up about one hectare (Fuhriman, 2008).

Ghana cannot boast of recycling facilities to manage the high volumes of e-waste that is generated or imported into the country. There are no stringent regulations on disposal of electronic goods and this has made the dumpsite at Agbogbloshie an open dumping place, market and ready source of employment for many people; especially young men from Northern Ghana most of whom seem to have either little or no basic education. They go to the site and learn the job on hand.

Tonnes of e-waste reach Agbogbloshie yearly. For example, in 2009, about 171,000 tonnes of e-waste from consumers, repair shops and collection from communities reached the Agbogbloshie dumpsite to be manually recycled (Caravanos et al., 2013). One can say that every electronic object, component and material have value at the Agbogbloshie e-waste site.

A study by Amoyaw-Osei et al (2011) indicates that the total Electrical and Electronic Equipment (EEE) imported into Ghana in 2009 measured up to 215,000 tonnes and about 70% was second hand products, and that about 15% of these second hand electronics were not in good conditions to be sold. For that reason, a significant portion was meant to go to the informal e-waste recyclers. Also, most of the imported electronic devices were close to the end of their lifespans. Such items would be of no use in time and be discarded. This suggests that the large importation of such almost end-of-life electronic gadgets tend to increase the volume of e-waste in most of the developing countries.

Ghana has ratified the Basel Convention, which controls the trans-boundary movements of hazardous wastes and their disposal; adopted in 1989 and entered into force in 1992. However, each month, cargo containers arrive in the country illegally with tonnes of e-wastes from all over the world including countries which have ratified the Basel Convention. In Ghana (just like most developing countries), there are few infrastructure and protocols for the disposal and recycling of e-waste safely and legislations which deal with their flow and regulations for maintaining the environment and human health are not always effective (Asante et al., 2011).

The rate at which e-waste is dumped and processed at Agbogbloshie is increasing and disturbing. However, because of the economic benefits to the workers, even children are enticed to do these activities with even more worrying implications for their health. Electronic equipments contain many hazardous metallic contaminants such as lead, cadmium, and beryllium. Lead enters biological systems via food, water, air, and soil. Children are particularly vulnerable to Pb poisoning more so than adults because they absorb more Pb from their environment (Kishore and Kishore, 2009). Various studies have reported high levels of toxic heavy metals and organic contaminants in samples of dust, soil, river sediment, surface water, and groundwater of Guiyu in China. For example, Kishore and Kishore, (2009) observed in their study that the residents had a high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, gastric and duodenal ulcers as a result of the high levels of heavy metals exposure. Certain components of electronic products are made up of toxic hazardous substances which can pose risks to the health of humans and the environment. Hazardous heavy metals such as lead, mercury and cadmium are found in televisions and monitors of computers. Nickel, beryllium and zinc are also found in circuit boards (Needhidasan et al, 2014). These hazardous materials can cause adverse effect on health such as an increase in blood pressure. For example, in their

study that looked at the association between exposure to mercury and its effect on blood pressure, Choi et al (2009) found a positive association between blood mercury levels and Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). Their study involved Faroese whaling men who are members of a Nordic fishing community that exhibit a wide range of Methyl mercury (MeHg) exposure that primarily originates from consumption of pilot whale meat, their hair strands were analysed for the presence of mercury and an increased level of hair mercury concentrations were detected.

At Agbogbloshie, there are various activities specific to each part of the site, though one could observe that certain activities cut across most of the areas. For example, there are specific places one can see solely dismantling of fridges, air conditioners, car parts, televisions and computers taking place but sorting of wires seems to run across the site. In this study, a Global Positioning System (GPS) device was used to demarcate the area into activity spaces in order to estimate the burden of various skin conditions like scars, rashes, skin peeling, and burns unique to each demarcated area and across space for effective intervention. The study also sought to estimate the prevalence of injuries like cuts, abrasions, avulsions and lacerations that they sustain as a result of their coming into contact with sharp objects during dismantling as well determine blood pressure levels among e-waste workers in each demarcated activity space.

1.2 Statement of the Problem

Space influences health outcomes when it comes to where people stay, do a type of work. At the Agbogbloshie e-waste site, it is known that the various e-waste activities which are mainly sorting, dismantling and burning impact on health outcomes.

As the e-waste workers (EW) go about these activities, they come into contact with hazardous substances. These have adverse effects not just on systemic organs, but also on

the skin resulting in conditions such as rashes, dermatitis, skin peeling, skin allergies, scars and burns. Also, the handling of sharp objects as well as working with most of the e-waste materials put them at risk of getting injuries such as cuts, abrasions, avulsions and lacerations. Numerous studies have been done to look at the effect of e-waste activities (EA) on the environment and health (Oteng-Ababio, 2012, Asante et al., 2011). However, none of these markedly mapped activity profiles with particular outcomes and for that matter this study was conducted to evaluate the impact of specific e-waste processing activities on skin conditions and other key health outcomes such as cuts, abrasions and lacerations.

For the deployment of effective interventions to reduce the health consequences associated with e-waste work, this study sought to provide evidence-based information on the spatial distribution of e-waste activities and their associated health outcomes.

1.3 Objectives

1.3.1 General objectives:

The general objective of this study was to conduct a spatial assessment and analysis of health conditions associated with different e-waste activities at different activity spaces at Agbogbloshie.

1.3.2 Specific Objectives:

Specifically, this study sought to:

1. Conduct a mapping of different e-waste processing activities occurring at defined spaces at the Agbogbloshie dump site.
2. Determine the prevalence of common injuries and skin conditions among e-waste workers in each activity area.

3. Assess both systolic and diastolic blood pressure among e-waste workers working in the different activity spaces.
4. Assess health seeking behaviour of the e-waste workers and their desire for an on-site first aid clinic at the Agbogbloshie dump site.

1.4 Hypothesis:

Health conditions at the different e-wastes processing activity areas are the same (i.e. there is no difference in the health conditions observed among e-wastes workers in different activity areas).

1.5 Conceptual framework

E-waste materials are collected from shops, homes, towns in and out of Accra. These collected items are brought to the e-waste dumpsite and sorted into various categories; those that could be repaired for re-use and those that have to be processed. The processes include dismantling using hammers, bare hands, spanners and chisels and then burning to release copper and other precious metals. Through all these activities, e-waste workers are exposed to harmful chemicals and the possibilities of being hit accidentally by the instruments they work with, falling or tripping. These then result in injuries such as burns, cuts, abrasions and lacerations. Also, activity could result in skin peeling, burns, rashes resulting in scarring as well as hypertension. This has been summed up in figure 2 below.

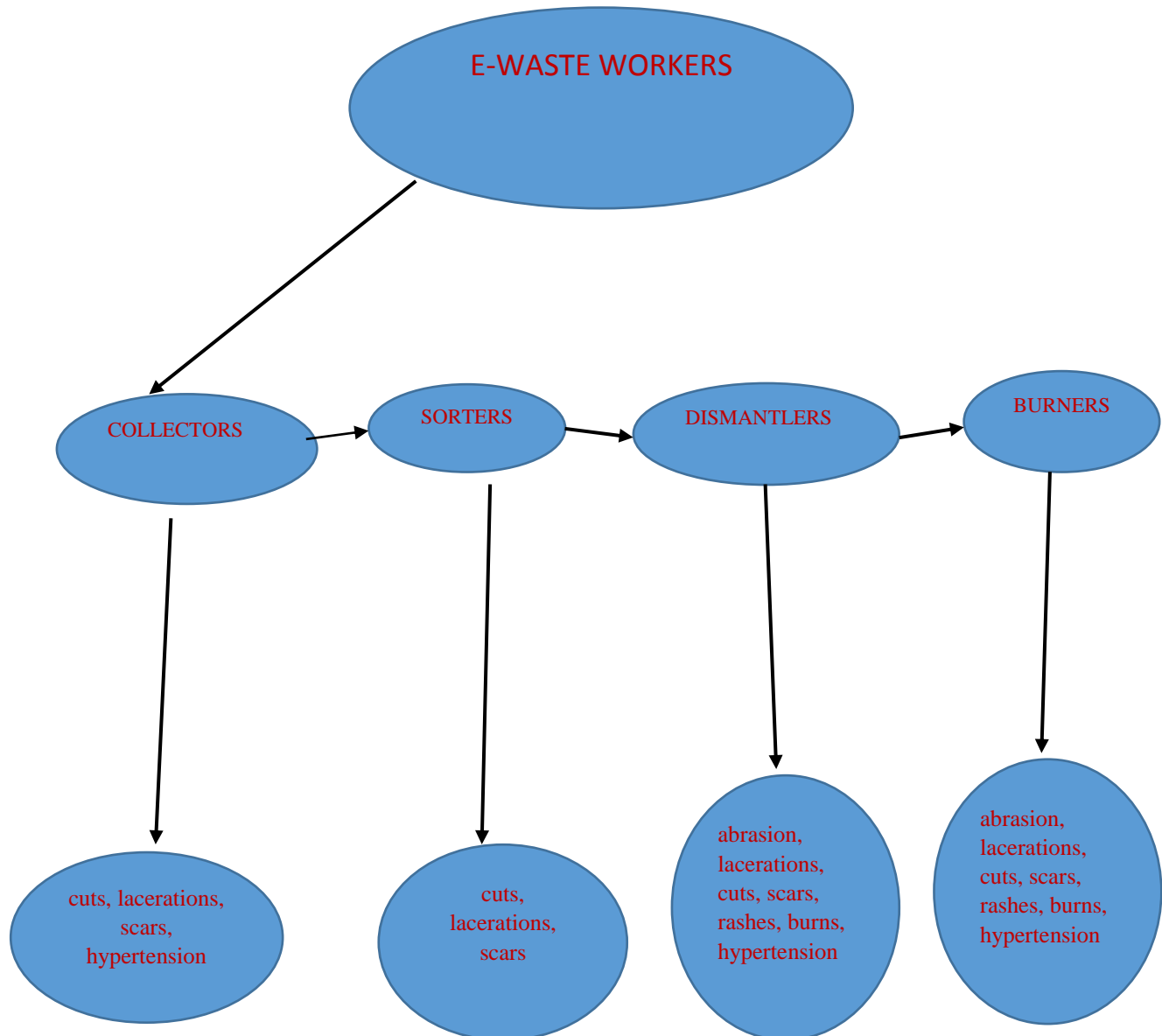


Figure 2: Conceptual framework.

1.6 Justification

Each day a vast number of electrical and electronic devices end up as waste and this has become a source of employment for a number of people. The amount of electronic devices entering the waste stream increases as the days go by and that means continuous stay in business for these e-waste workers. So far as there is no national policy on e-waste disposal and the fact that there is a continuous supply of waste to the e-waste workers

mean that they will continually be exposed to the negative health effects. A number of studies have been done to look at the various effects of e-waste activities on human health and the environment, but there are few, if any that specifically looked at the effect on the skin and the specific injuries the e-waste workers at Agbogbloshie are exposed to. This study, therefore sought to find out the burden of injuries, skin conditions, an increase in blood pressure among e-waste workers at different activity spaces at Agbogbloshie as well as their health seeking behaviour and the desire of the e-waste workers for an on-site first aid clinic. It was anticipated that the findings of this study will serve as a guide to any future intervention on e-waste management in Ghana.

1.7 Limitations of the Study

The study was limited to informal e-waste workers at Agbogbloshie. Language barrier was a limitation to this study. Most of the workers used for the study spoke and understood mainly Dagbani and this was unfamiliar to the researcher. Due to poor records on statistics of various categories of e-waste workers at the Agbogbloshie site, that is, not having records on the exact number of workers involved with collecting, sorting, dismantling and burning, appropriate sample size could not be computed. Only workers available at the time of the study who met inclusion criteria were recruited into the study. The success of the data collection depended mainly on the assistance of research assistants who were well versed with the language. The study subjects included only collectors, sorters, dismantlers and burners of e-waste materials. The study did not consider the workers who were involved with other e-waste activities such as the refurbishers and transporters. Only males were used as study subjects. No female was identified to be involved with any of the e-waste activities of interest, though a handful of them were engaged in other activities at the site. Only GPS device, questionnaire and direct observation were used as means of data collection. The period for the data collection spanned from 9th to 17th May, 2015.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This literature review discussed how a number of studies have described the various e-waste activities and also the relationship between e-waste activities and injuries, skin conditions and blood pressure. It looked at the various e-waste activities and their association with injuries, skin conditions, blood pressure and desire of the e-waste workers for a first-aid clinic at the Agbogbloshie dump site.

2.2 Definition of E-waste

E-waste, known also as electronic or electrical waste, is a term used to describe discarded electronic devices which use either electricity or battery to operate. They include computers, washing machines, televisions, refrigerators, sound systems, mobile phones, cathode ray tube (CRT), desktops, laptops, CRT monitors, liquid crystal display (LCD) monitors, keyboards, computer mice, printers, copiers and many more.

Very large quantities of discarded e-waste materials that are generated in developed countries continue to reach developing countries where untrained and ill-equipped persons extract valuables from the e-waste in a manner that put their health in danger (Eneh et al., 2011). In a study by Puckett et al. in 2002, it was observed that less affluent countries are the market grounds for processing used electronics. In Nigeria alone, it is estimated that 500 containers of used electronics enter Lagos. It is estimated that 10,000 to 13,000 metric tonnes of e-waste are handled annually in Ghana (Prakash et al., 2010).

Hundreds of tiny components are put together to constitute electronic devices and of these, many contain chemicals which are hazardous to human life. As a result of improper recycling and disposal processes used, the workers are exposed to these harmful

chemicals. “In electronic repair or refurbishing, health and safety issues, mainly arise from the risks of exposure to substances inherent in the electronic device they are working with” (Ideho, 2012). For example, hazardous materials like acid in batteries, mercury and cadmium in televisions and monitors of computers, nickel, and zinc in circuit boards (Needhidasan et al., 2014).

The type and age of an electronic product give an indication of its composition. For example, it is said that scraps from information technology and telecommunication systems contain a higher amount of precious metals than scrap from household appliances (Premalatha et al., 2014).

Electronic devices have been grouped into three main categories and these are:

- ✚ White goods- these include household electrical appliances such as blenders, microwaves, rice cookers and others.
- ✚ Brown goods- electrical devices that fall here includes televisions, camcorders, cameras and others
- ✚ Grey goods- computers, printers, fax machines, scanners and others fall under this category.

It is said that wastes from white and brown are less toxic as compared to those from grey goods category (Needhidasan et al., 2014).

A recent review on e-waste and health revealed that informal recyclers at one dumpsite in Mexico City were reported to have a shorter life expectancy of only 39 years (Binion and Gutberlet 2012).

Each e-waste activity poses health problems for the e-waste worker and it does not look like there is going to be an end to these informal recycling activities because these seem to be generating substantial amounts of money. It has been revealed in a study that though

health hazards that associated with e-waste activities were evident, stakeholders in the informal management of e-waste were willing to continue in the trade because of the economic benefits it offers (Ideho, 2012). These informal activities with their attendant health and environmental hazards are said to be a 700 million dollar industry now (Grant and Oteng-Ababio, 2012).

2.3 Collection of E-Waste Materials

E-waste activities start with the collection of the e-waste materials. It involve one category of workers usually referred to as scavengers combing through the various cities, towns, shops, workplaces, homes, in and outside Accra to collect various electronic items free of charge or at a cheaper rate, which are then taken to the Agbogbloshie e-waste site and sold to the workers. This serves as the main source of materials for the other e-waste activities. The other workers in the production chain depend on the items that are brought by the collectors (Okolo, 2013). In their study in India, Prakash et al (2010) also observed a similar situation. They observed that collectors move around the city with wooden carts picking up discarded or unwanted electronics and scrap metal which they take to the yard to sell. Initially, a collection of e-wastes from homes was done without paying any fees, but with increasing competition and the awareness about the potentials of used electronics, collectors now part with money to obtain e-waste (Oteng-Ababio, 2012). This is corroborated by the findings of Manhart et al. (2011) where they observed that collectors bought obsolete Waste Electrical and Electronic Equipments (WEEE) for small amounts of money from businesses or private households. For collectors who could not pay for these WEEE, getting these for free or resorting to refuse/waste dumps became their option.

2.4 Sorting of E-Waste Materials

Electronic wastes mostly get to the Agbogbloshie e-waste site by trucks, carts, and taxis. Accordingly, they are sorted into those that can be reused, or broken down or burnt to extract precious metals. Devices of the same kind are grouped together. For example, refrigerators, televisions, stereos, microwaves, computers, car parts are respectively put together. In India, accumulated WEEE are manually sorted to fractions such as printed wiring boards, CRTs, cables, plastics, metals, condensers and invaluable materials like batteries (Sardinia, 2007). It is a livelihood for recyclers and because they are unaware of the adverse effects, they risk their health and that of the environment. In relation to this, Huo et al. (2007), observed in their study that plastics, (e.g., polyvinyl chloride (PVC), high-density polyethylene (HDPE) were sorted by workers according to rigidity, colour, and lustre. Plastic scraps that cannot be sorted visually must be burned and classified by burning odour. In his study, Ideho (2012), mentioned that exposure to the toxic substances contained in e-waste can occur through cuts from broken CRTs, constant exposure to hazardous substances (such as dioxins and mercury from burning) during sorting at the dumpsite or during CRT crushing operations with the intent to extract metals within them and that unwanted parts were thrown into the open fire for burning.

2. 5 Dismantling of E-Waste Materials

E-waste materials that come to the dismantling zones are disassembled into various component parts. This is usually done with chisels, hammers, screw drivers and pliers. At Agbogbloshie, the use of a screw driver which has been nicknamed “star” was employed in unscrewing computer to access the various valuable components (Akormedi, 2012). Dismantling of WEEEs may potentially bear an increased risk of injury. As the workers go about with this activity, these instruments may hit them mostly on their hands to cause blunt injuries or open wounds.

Another risk associated with the dismantling of e-waste is the accidental releases and spillages of hazardous substances contained in these WEEE. For example, mercury, found within light sources (e.g., fluorescent tubes in scanners, photocopiers) as well as switches, could be released into the air of a recycling yard upon breakage of those parts (Aucott et al., 2003). Primitive means of disassembling WEEs are mostly employed at the site. This parallels a study by Huo et al. (2007) which observed that in Guiyu, China, e-waste recycling procedures were mainly primitive and included the following: Dismantling of electronic equipment was done with a hammer, electric drill, cutter and screwdriver into component parts such as monitor, hard drive, CD driver, wires, cables, circuit boards, transformer, charger, battery, and plastic or metal frame that are sold for reuse or to other workshops for further recycling.

The dismantling activity is very tedious and needs strength to undertake it. Sometimes, direct pressure needs to be applied to separate certain parts. The raising of hammers, as well as drilling and other dismantling processes require a lot of energy and is mostly done by young and energetic men. Dismantling is mostly physical and may make use of tools like wrenches and drills or other moderately specialized equipments (Sthiannopkao and Wong, 2012). No machines are available to go about the dismantling activities. Every dismantler has to rely on the use of his hands to go about the work. An observation by Kurian (2007) confirms this. He observed in his study that the workers did not make use of any sophisticated machinery and that they had to work with the help of hammers and screwdrivers.

2.6 Burning of E-Waste Materials

Burning is one of the main e-waste activities. It is carried out at a small distance from where the other e-waste activities take place. Substances believed to contain copper, aluminium, gold and other precious metals are thrown into the open fire for them to be

burned in order to expose the precious metals. The open burning is also done to reduce waste volumes of plastic parts. Valueless electronic parts are burnt to dispose them off in open fires. All these activities are associated with health hazards. Similar reflection was shared when a researcher observed from his work that components of e-waste which have no value are burnt openly and this is associated with pollution problems (Kurian, 2007). Toxic smoke is generated as a by-product during the burning process. This smoke has been reported to contain extremely toxic chemicals with serious health effects on both e-waste recyclers and the surrounding populations (Akormedi, 2012). Such toxic chemicals include dimethylene mercury, dioxins and furans (Noble, 2008).

Recycling is done by heating and manual removal of components from printed circuit boards, open burning of wires of various sizes to reduce waste volumes in order to facilitate recovery of metals such as copper and other precious metals (Yang et al., 2012).

Informal recycling of e-waste also poses dire occupational and environmental implications, especially when necessary PPE is not easily available to the recyclers. In a study, it was observed that the workers adopt primitive methods without making use of PPE. For example open fires are tended by children, who are paid by dealers collecting metals such as copper (Kishore and Kishore., 2010).

Circuit boards of computers and other large appliances were heated over coal fires to melt the solder to release valuable electronic components, such as diodes, resistors, and microchips. “Circuit boards of cell phones and other hand-held devices were taken apart by an electro-thermal machine, which was a particular environmental and human health concern in the processing of e-waste in Guiyu. Wires and cables were stripped or simply burnt in the open air to recover metals” (Huo et al, 2007). In their study, Chi et al. (2011)

reported that the removal of components from printed circuit boards was done by heating over coal-fired grills.

It is important to mention that EW who are involved with the burning of WEEE do not use any approved PPE as can be captured in a response one of the EW when asked whether he uses PPE during burning. He said “I don’t rely on safety equipment when I am burning electronic waste except some heavy shoes which protect me from the fire” (Akormedi et al, 2013).

2.7 Health Conditions Associated With E-Waste Activities

2.7.1 Skin Conditions

As a result of various e-waste activities, the e-waste worker comes into contact with various hazardous substances. These hazardous substances are found within the various EEEs that the workers work on. At the e-waste site the workers are found going about their e-waste activities without PPE such as utility gloves, goggles, facial masks, aprons and protective footwear. Not wearing PPE while undertaking various e-waste activities put the skin of the workers at risk of coming into contact with hazardous and ‘unfriendly’ chemicals such as nickel, beryllium, mercury, copper and others. The skin reacts to these chemicals and as a result, skin allergies, peeling, dermatitis, rashes and chemical burns can occur. These may be serious health hazards and sometimes emergency medical care is urgently needed. For example Beryllium exposure is said to cause a form of skin disease that is characterized by poor wound healing and wart-like bumps (Agency for Toxic Substances and Disease Registry, 2011). Studies have shown that people can still develop beryllium disease after many years following the last exposure (Puckett et al., 2002).

Mercury (Hg) is used in the manufacture of parts of electronic devices such as thermostats, sensors, relays, switches commonly found on printed circuit boards, mobile phones and in

batteries. As an alternative to cathode ray tubes, the use of mercury is likely to increase in flat panel displays (Idehi, 2012). During an e-waste activity such as dismantling, there could be spillage of mercury from a WEEE that contains it, and this can accidentally get into contact with the skin to cause various skin conditions such as rashes, injuries and scars (when the rashes and injuries heal). According to the World Health Organization (WHO), Hg may cause skin rashes, skin discoloration, scarring as well as a reduction in the skin's resistance to bacterial and fungal infections.

Another element of interest is Nickel which is found in printed circuit boards in computers, music players, electronic gear, some batteries (Greenerchoices.org) and cell phones. A report by Mayo Clinic indicated that nickel causes skin allergy and it is one of the most common causes of allergic contact dermatitis, which is an itchy rash that erupts when one's skin touches an unusually harmful substance. The allergy usually develops after repeated or prolonged exposure to items containing nickel. It is worth mentioning that once a person develops a nickel allergy, that person will always be sensitive to the metal and need to avoid contact (Mayo Clinic).

Guiyu in China, is famous for being among the top e-waste sites in the world. According to a study undertaken by Kishore and Kishore (2009), high incidence of skin damage among residents of Guiyu, was commonest among the list of the effects of e-waste activities. Furthermore, a study by Qiu et al. (2004) also came out to say that "among the residents of Guiyu there were high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers, all of which may be caused by the primitive recycling processing of e-waste."

Healing of these most of the time leaves the affected EW with multiple scars.

2.7.2 Injuries

Appropriate PPEs like hand gloves could prevent cuts, lacerations and other injuries to the hands, facial masks could help in reducing the inhalation of fumes and dust, eye shields or goggles will help in preventing foreign bodies from going into the eyes as well as prevent injuries to the eyes. Safety shoes will also prevent injuries to the feet and overall gowns reduce exposure to foreign objects so close to the body to cause harm. However, it is not uncommon to see EW go about their various activities without making use of PPEs. Fu et al. (2011), observed in their study in Southeast China that the EW work without using facial masks, goggles or protective goggles. As a result, they are prone to so many injuries which otherwise could have been minimized. The injuries may be due to being hit by work instruments, such as hammers. Cut by any of the electronic waste materials with sharp edges, trips and falls at the working site, stumbling over an electronic waste material or sustaining various degrees of burns as a result of burning. The injuries they are exposed to include cuts, lacerations and abrasions. All too soon many of the sustained injuries get infected because most of the workers resort to crude methods of caring for wounds instead of going to the hospital for the wounds to be properly cared for.

In a study conducted by Chikharmane et al. (2009) in India, they found that EW were at a higher risk of work related accidents and were more likely to suffer physical injuries and physical disabilities than the general population.

In the course of going about their activities, EW come into contact with WEEE with sharp or pointed ends. Some of these may also be broken into pieces. All these put them at risk of sustaining various degrees of injuries.

Injuries on hands and feet result from sharp WEEE. CRTs are chief contributors to injuries. In separate studies by Manhart et al (2011) and Kurian, (2007), the following

observations were made respectively; for the workers who engage in recycling of CRTs, cuts and injuries from breaking the tubes were common and the breaking of CRT result in injuries from cuts. These e-waste workers mostly worked with their bare hands without the use of PPE.

For the workers who even know the importance of PPE, they do not use the recommended ones. For them, anything to which seems to give some form of protection was good to use. In their work, Akormedi et al. (2013) observed that many of the EW did not use any form of PPEs apart from some heavy shoes that few seldomly used and so they frequently reported of burns and cuts to the hands. Some EW were on record to have said the following:

✚ “I use heavy shoes to protect me from cuts on my legs, I don’t use gloves, but what I do is I don’t get close to where they do the burning and in case I am passing by I use duster to cover my face, nose and eyes.”

✚ “I admit the work affects me. I hope you see the cuts on my palm, they are indeed from the job.”

Throwing more light on injuries associated with e-waste activities, a United Nations (UN) Report of 2014 states that the collection and recycling of heavy and sometimes e-waste materials with sharp edges lead to spinal injuries, cuts and infections.

2.7.3 High Blood Pressure

There are two main types of blood pressure and these are the Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). The World Health Organization, (WHO) recommends using the average of three blood pressure readings at one visit in risk factor surveys. Blood pressure is said to be high if it is checked consistently for three consecutive times and reading is above 140/90mmHg. During literature review for this work, no study

was found to have concluded that e-waste activities on their own cause high blood pressure (HBP). The emphasis, however, was on the chemicals that the e-waste workers are exposed to as a result of the work they do. Among the risk factors for getting HBP is exposure to certain chemicals found in WEEE such as Hg and Pb.

Articles and studies reviewed mentioned the association between chemicals like Pb and Mg and an increase in blood pressure. As stated earlier, Hg is found in a lot of the WEEE processed by e-waste workers. It naturally occurs in the soil, but mercury in its organic form is also released into the aquatic environment where bacteria and algae transform it into MeHg (Patrick, 2007), making it possible to accumulate in predator fish and marine mammals (Valera et al., 2009). People who live around these water bodies and consume aquatic animals which contain MeHg are predisposed to accumulating mercury, commonly found in the hair. This is consistent with the study by Fillion et al. (2006) that looked at mercury exposure and blood pressure in the Brazilian Amazon. They reported a higher risk of increased SBP among subjects with higher mercury hair levels.

Furthermore, in a study that looked at Nunavik Inuit tribe in Northern Quebec, Canada, adults who were highly exposed to environmental mercury, Valera et al. (2009) assessed the association between mercury levels and BP considering possible confounding factors, such as age, sex, obesity, cholesterol levels, insulin sensitivity, smoking, alcohol consumption, physical activity, lead, and socioeconomic status, they observed that there was a positive association between mercury levels and BP among these adults whose diet was mainly traditional food (sea foods) and concluded that blood mercury concentrations were associated with increasing SBP after the confounding factors were controlled.

In a study conducted by Vassallo et al. (1995), they indicated that in the cardiovascular system, acute inorganic mercury exposition in vivo promotes reduction of myocardial

force development and inhibits myosin ATPase activity (Moreira et al., 2003). Long term exposure to inorganic mercury increases vascular resistance and induces hypertension (Azavedo et al., 2012).

In experimental studies, it was observed that rats that have been chronically exposed to MeHg developed systemic hypertension that persisted for many months after exposure and an increased BP was also detected in rats exposed to MeHg for 26 days (Wakita, 1987; Tamashiro et al., 1986).

Allam (2010) made known that Pb occurs commonly in circuit boards and cathode ray tubes and it causes damage to red blood cells, kidneys and also potential increases in high blood pressure. Burning of WEEE containing lead can result in the release of the element to the air.

EW stand at higher risk of getting HBP because they are constantly exposed to many hazardous chemicals including those that put them at risk such as Barium. It is a soft silvery-white metal that is used in computers in the front panel of a CRT, to protect users from radiation. Studies have shown that short-term exposure to barium has caused brain swelling, muscle weakness, damage to the heart, liver, and spleen (Agency for Toxic Substances and Disease Registry, 2011). There is still a lack of data on the effects of chronic barium exposures to humans. Animal studies however, reveal increased blood pressure and changes in the heart from ingesting barium over a long period of time.

2.8 Health seeking behaviour and the need for an on-site first aid clinic

When workers are healthy, a more productive workforce results. Workplace first aid clinics offer occupational health services to the workers in order to ensure their optimal health. In many industries, on-site clinics are run by health care organizations in collaboration with the employers or the employers set their own clinics and employ

healthcare workers to man the facility. In 2011, it was estimated that 31% of employers with 500 or more employees in America utilized on-site clinics (Employee Health and Wellness Centres). The business community needs the services of the medical community to integrate into the workplace to ensure the health of the workforce. The range of services of worksite clinics may include occupational health such as treatment of work-related injuries (Shahly et al., 2014).

Due to the hazardous nature of their work, high risk occupational groups are expected to have access to medical care on site to attend to their emerging and emergency health needs and these workers desire for on-site clinics. Most often than not, these workers lack access to any medical assistance on site. In a study dubbed GMS TRIANGLE Project which was undertaken by the International Labour Organization (ILO/GMS Triangle Project, 2013) to look at accessibility of first aid services to fishermen on fishing vessels, more than one-quarter of these vessels did not have first aid kits on board despite the fact that their work was dangerous enough to send one out of five fishers to a clinic or hospital as the result of a work-related injury.

Most informal workers, like EW, work under unsafe conditions, carrying out dangerous activities which may result in injuries and diseases, but most of them are not covered by the formal healthcare system. Most informal workers ignore the danger of their performed activities because they have become all too familiar with them (Gunsilius et al, 2011). ACEPESA, 2010, puts it that the tendency not to recognise personal health problems could be explained by a sense of shame or fear of being criticized. Whereas some of the workers often nurture the desire to have an on-site clinic to attend to their health needs, especially in times of injury, others are not so particular about having an on-site clinic. Many of them do not seek healthcare from recognized healthcare facilities and limited finances make these workers resort to different avenues to seek healthcare. For religious

reasons and other beliefs, most of the informal workers seek unorthodox healthcare. For those seeking orthodox healthcare, the majority of them tend to self-medicate, or turn to cheaper and quack doctors. Pointing to the entrenched health-seeking behaviour patterns of waste pickers, Samarth (2014) noted that most waste pickers sought medical intervention from local neighbourhood doctors in order to cut costs and travel time but most of those doctors engaged in forms of malpractice.

CHAPTER THREE

METHODS

3.1 Overview

This chapter discusses the techniques and approaches which were employed to meet the objectives set for this study.

3.2 Type of Study Design

Descriptive cross-sectional study design was employed for the study. It helped in assessing the status of the selected e-waste workers with respect to the e-waste activities and how they were related to the outcome of interest at the same point in time.

3.3 Study Location/Area

The study was conducted at the Agbogbloshie e-waste site which is one of the largest e-waste dumps in the world. Agbogbloshie, known also as Old Fadama, serves as a home to about 40,000 people (Feldt et al, 2014). It is one of the biggest slums in the world. It is less than one kilometre from the Central Business District of Accra and is about thirty-one hectares in size (Oteng-Ababio, 2012). It is bounded south, west and northwest by the highly polluted Odaw River which feeds into the Korle Lagoon.

Accordingly, the locality of Agbogbloshie serves not just as homes to thousands of people and e-waste site, but is also noted for the popular Agbogbloshie Market where all sorts of farm produce and wares are sold, popular among onions and yams. This draws thousands of patrons to the locality on a daily basis.

3.4 E-waste processing and recycling

Computers and televisions are regularly disassembled and disintegrated into their constituent materials-plastics, glass, and metals. Plastic printer cases are smashed with

rudimentary tools including hammer, spanner, chisel and even the bare hands (Oteng-Ababio, 2012).

A visit to the site shows workers busily making use of hammer, spanner, chisel and even the bare hands to dismantle various parts of cars such as car batteries, engines, hammering of the bonnet and sorting out various sizes of wires and electronic devices such as computers, stereos and household items like blenders, microwave ovens, rice cookers and so many others. There are some of the workers who, after manually recycling some of the electronics are able to use the recovered items to make useful new products which are made available for sale. For example, some of the workers are able to hammer metals from various electronics, pass them through fire to manufacture iron cooking pots of various sizes. At this particular site one can really feel the high temperatures that the fires produce and yet the workers are found to be in the heat constantly doing this work. Also, others are able to repair broken screens of computers or the repair of items such as televisions, stereos and mobile phones and all these are available for sale at a much reduced price. Noteworthy among the activities at the site is the open burning of wires to remove copper and other metals. One will observe many of the workers gathered around the fire during this process, not paying attention to the toxicity of the presumably contaminated smoke emanating from this process. The sorting out of old refrigerators, air conditioners, washing machines into those that could be repaired for sale or dismantled is a commonplace.

Most of the recycled products have ready markets. For example, at the site one sees a lot of trucks with dismantled electronics, mostly the metals ready to be sent out to iron rods manufacturing companies. Some individuals and companies also frequent the place to purchase certain items which can serve as raw materials for their works and personal use.

3.5 Study Population

The study was conducted among workers at the Agbogbloshie e-waste site, Accra where e-waste processing activities take place. The workers have formed an association, the Accra Scrap Dealers Association, and as at the time of conducting this study, registration was still ongoing. The number of registered workers stood at three thousand (3,000) and this comprised not just collectors, sorters, dismantlers and burners, but also drivers who cart the scrap metals to Tema and refurbishers. This number is comprised of association members also from Madina (suburb of Accra) and Kasoa (suburb of Central Region but in close proximity to Accra). Through their activities, they are able to generate high volumes of ferrous and non-ferrous metals to meet the needs of the steel industry. There is no formal arrangement in recruiting and training people as e-waste workers. Academic qualification is not needed either. One has to be strong physically and healthy as the work is mainly physical, requiring a lot of energy and skills of the work are learnt on the job. Most people learnt the skills from friends and relatives who were already in the work. The work is done mostly by males, however, some females have begun showing some interest in these activities and so a handful of them were found there as well.

3.6 Variables

3.6.1 Dependent variables (outcome variables):

- injuries: cuts, lacerations, abrasions, avulsion
- skin conditions: rashes, scars, burns, allergies, dermatitis, peeling
- high blood pressure

3.6.2 Independent variables:

E-waste activities:

- collection

- sorting
- dismantling
- burning

3.7 Sample Size

Various activity spaces were mapped. The workers were found mainly in small groups at the various activity spaces. Since there were not many e-waste workers at the various activity spaces at the site, all workers who were working and willing to participate in the study as well as meeting the inclusion criteria were sampled for the study. The total number of participants came to one hundred and twelve (112).

3.8 Sampling Method

Convenient sampling was employed to recruit 112 workers from the various activity spaces at the e-waste site after mapping had been done. Using this method ensured that subjects selected met the inclusion criteria and were able to provide useful information that enriched the study.

3.8.1 Inclusion Criteria

Only e-waste workers who had worked at the site for six months or more and were involved with the collection, sorting, dismantling and burning of e-waste materials were recruited for the study. The justification for the inclusion of workers who have worked for six months and above was that it was assumed that workers who have worked for this period would have been exposed to more hazards at the e-waste site, increasing their risk for sustaining the various outcomes of interest as compared to someone who had worked for a period which is less than six months.

3.8.2 Exclusion criteria

Exclusion criteria were an e-waste worker who had worked at the site for less than six months and other workers at the site who were not involved with collection, sorting, dismantling and burning of e-waste materials.

3.9 Data Collection Techniques

An Electronics and Telecommunications Research Institute (ETRI) Geographical Positioning System (GPS) device manufactured in South Korea was used to map out the various activity areas at the dumpsite making use of longitudes and latitudes. Then, there were direct examination of the skin for injuries and skin conditions, measurement and recording of systolic and diastolic blood pressure of all study subjects by the principal investigator and a research assistant who was a qualified nurse. A translator and three other trained research assistants assisted with questionnaire administration. The use of a questionnaire was employed to collect demographic data on all participants and elicit responses of study subjects on various variables of interest for the study as well as collect information on knowledge and use of PPE among the workers. This helped in assessing the relationship between e-waste activities and high blood pressure, injuries and various skin disorders of interest as well as their felt need for a first aid clinic. All study participants were assigned a unique identity (ID) comprising of a prefix. The prefix was assigned based on a particular activity space participants were sampled from. Based on that, the following prefixes were used;

- ✚ COR- Collecting
- ✚ SOR- Segregation
- ✚ DIS – Dismantling
- ✚ BUR- Burning

Factors such as age, history of high blood pressure, old scars before starting work, injuries and burns not sustained at the e-waste site were assessed to control for possible confounding.

Physical examination of the skin was done to verify the presence of injuries and these were classified into the various injuries the study looked at. Scars sustained at work were counted on both hands and legs. Workers pointed out which ones were sustained at work and the others sustained out of work such as scars from healed motorbike injuries. Systolic and diastolic blood pressure of all study participants were checked three consecutive times with a calibrated digital Omron Blood Pressure Monitor manufactured by Omron Corporation, Japan. The mean was found for both systolic and diastolic blood pressure for each study subjects per World Health Organization (WHO) standard of diagnosing hypertension.

3.10 Data Collection and tools

The use of a GPS device for mapping, questionnaire with relevant questions meant to generate responses to meet the objectives of the study and direct skin examination were employed.

3.11 Quality Control

In order to ensure the quality of the data, a translator and three other trained research assistants, one of whom spoke and understood Dagbani assisted with questionnaire administration. Furthermore, the services of a qualified nurse was employed to assist the researcher who had six years' experience of checking blood pressure to undertake blood pressure reading and skin examination of all participants. Technical terms were explained briefly in simple words on the questionnaire in order to ensure that they were well understood. Code numbers were assigned to each participant instead of using their names.

This was done to enhance the confidentiality and privacy of participants. All information obtained from the e-waste workers have been kept highly confidential and will only be used for academic and developmental research.

3.12 Data Processing and Analysis

Points taken with the GPS device were entered into excel to generate longitudes and latitudes and these were exported into ArcGIS 10.1 for mapping. The completed questionnaires were crosschecked by the principal investigator. These were all entered into Epi Info™ 7 software. They were then entered into Microsoft Excel to be recoded. These were subsequently exported to Stata Version 12. The data were cleaned before running the analysis. The use of Pearson's Chi square was employed to test for differences in the various variables of interest in the activity spaces. Fischer's exact p-value was used where there was a low cell count, below 5. Fischer's exact p-value, however, was not employed in multiple response cases. Tables and graphs were then drawn from the output from Stata. The use of analysis of variance (ANOVA) was employed to test for association between activity space and the mean systolic and diastolic blood pressure. For the relationship between two variables to be significant, the generated p-value should be ≤ 0.05 , error margin, with a significant level of 95%. Multiple responses were allowed for various injuries and skin conditions. For example, one person could have more than one type of injury. In Stata, mrtab was employed to tabulate multiple responses.

3.13 Ethical Consideration

Ethical clearance was sought from the Ghana Health Service Ethical Review Board. Also, permission was sought from the Chairman and Secretary of the Accra Scrap Dealers Association. Furthermore, a participant information sheet which described briefly the activities and importance of the study were read to all study participants and consents were obtained from them before the study; those who could append their signatures did so and

those who had to thumbprint were given ink pad to that effect. The participants were also made aware that the study was a non-invasive one. This was done to allay their anxieties about any fear that they might have entertained regarding invasive procedures like taking a blood sample.

3.14 Pre-test/Pilot Study

Pre-testing was done at the Agbogbloshie e-waste site where refurbishing is done with five e-waste workers who were not part of the study. Appropriate corrections were made; certain medical terms were broken down and explained to the layperson's understanding.

CHAPTER FOUR

RESULTS

4.1 Overview

Findings in relation to the objectives of this study are presented in this chapter. It brings to the fore mapping of the different e-waste processing activities that occur at the Agbogbloshie dumpsite as well as a description of the study participants, test of association between activity space and injuries as well as skin conditions that they are exposed to. Also, the result of assessed blood pressures of study subjects in the different activity spaces.

4.2 Mapping of different e-waste processing activities

As seen in figure 2, the following are the coordinates generated by the GPS device;

- ✚ WB - West bank, near the Abossey Okai road, this marked the beginning of points taking. Sorting takes place here.
- ✚ FA - Fridge area, indicated the beginning of the burning area
- ✚ SE – South end, heavy burning was done here
- ✚ SCP – South central point, minimal burning was undertaken here
- ✚ SCWB – South central west point, dismantling was mainly done here
- ✚ SWE – South west end, closer to Central Gospel Church; sorting and some dismantling took place here.
- ✚ MWE – Middle west end, closer to the football park; predominantly dismantling and some sorting
- ✚ BIF – Blacksmith institute facility, the chief of the scrap dealers association area, the association office; true recycling/ refurbishing was done here
- ✚ NEW – North west end, near Abossey Okai road side
- ✚ NCP – North central point, mainly dismantling

✚ WBE – West bank ends

Table 4.1 Table showing generated coordinates

Description	X (Longitude)	Y (Latitude)
BIF	-0.22478	5.553944
FA	-0.22653	5.552306
MWE	-0.22447	5.553111
NCP	-0.225	5.553778
NEW	-0.22642	5.554167
SCP	-0.22669	5.551056
SCWB	-0.22522	5.551528
SE	-0.22731	5.550583
SWE	-0.224	5.552472
WB	-0.22397	5.553278
WBE	-0.21667	5.553278

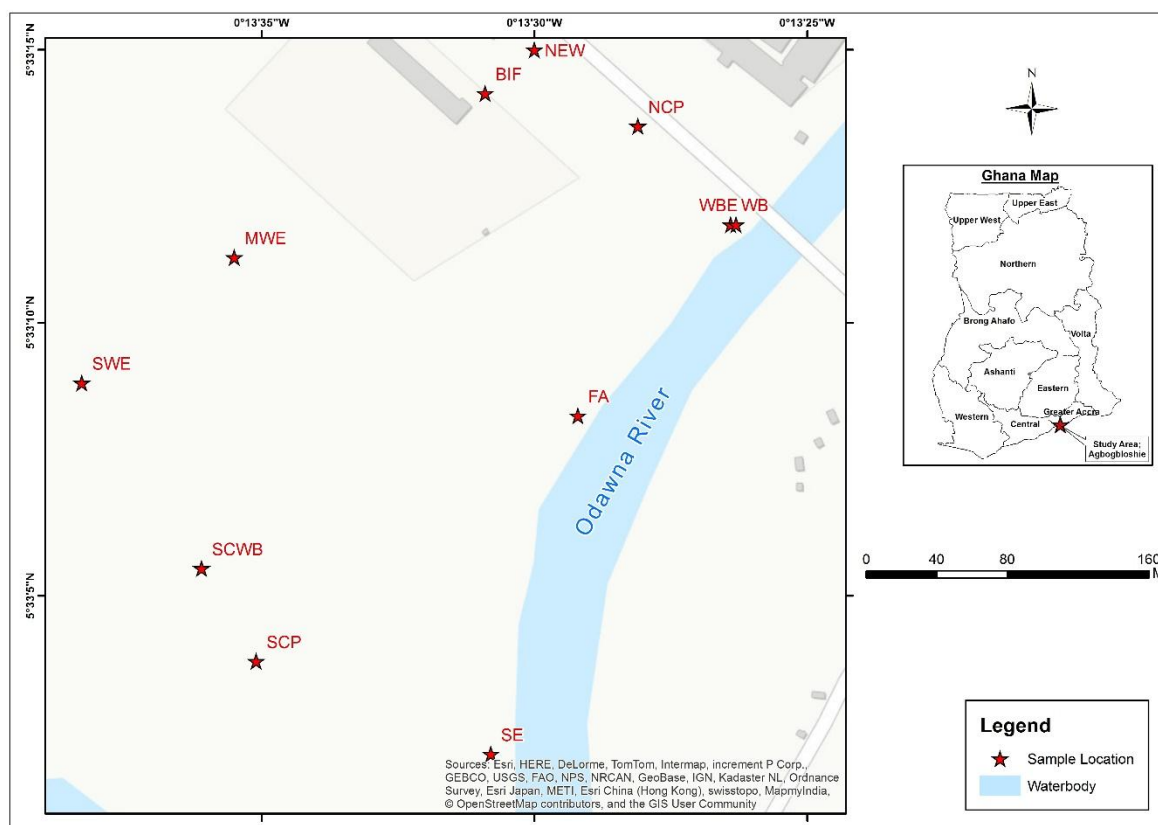


Figure 3: GPS-generated map showing different e-waste processing activities at Agbogbloshie

As could be seen from the graph, WB, FA, SE and WBE are all alongside the Odawna River. NEW, WB, WBE and NCP are the areas closest to the Abossey Okai road which leads to the popular Agbogbloshie market to the right and the Abossey Okai Traffic light to the left.

The coordinates were taken from the West bank of the Odawna River, close to the Abossey Okai road that leads to the Agbogbloshie market. This was predominantly an area for sorting. Progress was made and an area marked as fridge area saw the beginning of burning of e-waste materials and then to the South end of the e-waste site where the heavy burning took place. The South Central point of the site was also noted for some minimal burning. Dismantling was done mainly at the south central west point of the site. Sorting and some dismantling occurred at the South West end, closer to the Central Gospel Church at Agbogbloshie. Predominantly, dismantling and some sorting occurred at the Middle West end of the site. That point was close to the football park at the site. The area where the association office was located was noted for the refurbishing of e-waste materials into cooking wares and pots (popularly called “gyapa” in Ghana). No study subject was drawn from this area. North west end of the site, near the Abossey Okai road that led to the Abossey Okai traffic light saw some sorting being done there and the North Central point of the site marked another area for dismantling and from there the GPS reading was proceeded to the West Bank of the Odawna River for it to end. All these points are seen in figure 3. As a result of e-waste activities, the Odawna River is heavily polluted and this could be seen from the dirty colour of the river with all sorts of impurities.

4.3 Demographic Characteristics of the Study Participants

One hundred and twelve (112) e-waste workers at different activity spaces comprising of Collectors, Sorters, Dismantlers and Burners were recruited into the study. The demographic information of the participants is shown in Table 4.2 below.

Table 4.2: Demographic characteristics of study subjects

Characteristic	Activity space					Statistic; P-value
	Collecting	Sorting	Dismantling	Burning	Total	
Age						P=0.010
<20	3 (8.6)	1 (6.3)	7 (18.0)	9 (40.9)	20 (17.9)	
20 – 29	22 (62.9)	7 (43.8)	23 (59.0)	11 (50.0)	63 (56.3)	
30 – 39	8 (22.9)	6 (37.5)	8 (20.5)	0 (0.0)	22 (19.6)	
40+	2 (5.7)	2 (12.5)	1 (2.6)	2 (9.1)	7 (6.3)	
Mean (SD)	26.1 (6.8)	28.1 (7.6)	24.5 (6.1)	22.1 (9.9)	25.3 (7.5)	
Marital status						
Unmarried	16 (45.7)	6 (37.5)	18 (46.2)	10 (45.5)	50 (44.6)	
Married	19 (54.3)	10 (62.5)	21 (53.9)	12 (54.6)	62 (55.4)	
Highest education						P=0.314
None	16 (45.7)	8 (50.0)	11 (28.2)	4 (18.2)	39 (34.8)	
Primary	9 (25.7)	4 (25.0)	13 (33.3)	10 (45.5)	36 (32.1)	
Junior High	3 (8.6)	0 (0.0)	6 (15.4)	4 (18.2)	13 (11.6)	
Secondary	7 (20.0)	4 (25.0)	8 (20.51)	3 (13.6)	22 (19.6)	
Region						
Northern	33 (94.3)	14 (87.5)	33 (84.6)	20 (90.9)	100 (89.3)	
Others	2 (7.1)	2 (12.5)	6 (15.4)	2 (9.1)	12 (10.7)	
Ethnic group						
Dagomba	33 (94.3)	14 (87.5)	27 (69.2)	15 (68.2)	89 (79.5)	
others	2 (5.7)	2 (12.5)	11 (28.2)	7 (31.8)	22 (19.6)	
Length of work						P=0.497
6 - 12 months	4 (11.4)	1 (6.25)	4 (10.3)	4 (18.2)	13 (11.6)	
1 - 5 years	13 (37.1)	4 (25.0)	11 (28.2)	10 (45.5)	38 (33.9)	
> 5	17 (48.6)	11 (68.8)	24 (61.5)	8 (36.4)	60 (53.6)	
Daily working hours						
5 – 10 hours	9 (25.7)	3 (18.8)	9 (23.8)	5 (22.7)	26 (23.2)	
11 – 15 hours	24 (68.6)	12 (75.0)	30 (76.9)	16 (72.7)	82 (73.2)	

Fischer's exact p-value was used due to low cell count, below 5

Characteristic background of study participants considered were sex, ages, marital status, region, tribe, educational background, length of work and daily working hours. All the study participants were males. The ages of the participants ranged from 16 to 55 years. Sixty three (63) out of the 112 participants representing 56.3% were in their twenties and

6.3% of them were 40 years and above. Those between 20-29 years dominated the age group among the workers in each of the activity spaces. No worker in the age group 30-39 was found among the burners. There were more married workers than the unmarried. Fifty participants (44.6%) and 62 (55.4%) were unmarried and married respectively. 39 of them representing 34.8% had no formal education, 32.1% of them had primary education with 11.6% and 19.6% having had Secondary and Junior education respectively. Majority (89.3%) hailed from the Northern Region with 10.7% of them from the other regions of the country. 89 (79.5%) of study participants belonged to the Dagomba tribe.

There were two foreign nationals from Nigeria and Togo. More workers had worked for between 11-15 years (73.2%) whereas 23.3% worked between 5 -10 hours. 53.6% had worked for more than 5 years, followed by 33.9% and 11.6% for those who had worked for 1-5 years and 6-12 months respectively.

4.4 Prevalence of injuries at activity spaces

From table 4.3 below, it can be seen that cuts were generally common at all the activity spaces as compared to the other injuries. A total percentage of 96.2 of all the study subjects had cuts. Overall, dismantlers had a higher percentage of cuts (94.9) amongst them all. With a percentage of 90.9, the burners closely followed the dismantlers. Lacerations follow cuts with a percentage of 46.6 in all the activity spaces. Again, a higher percentage of 74.4 and 54.5 were recorded among the dismantlers and burners respectively. The trend was different for abrasions. Among the e-waste workers, the majority with abrasions were the dismantlers with 38.5%, followed by the sorters with 18.9%. The prevalence of abrasions was statistically significant between the different activity groups (chi-square; $p \leq 0.05$).

Table 4.3: Assessment of injuries at activity space

Characteristic Assessed	Activity space					Statistic P-value
	Collectors	Sorters	Dismantlers	Burners	Total	
Injuries^b						
Cuts	30 (85.7)	13 (81.3)	37 (94.9)	20 (90.9)	100 (96.2)	0.799
Lacerations	10 (26.3)	5 (31.3)	29 (74.4)	12 (54.5)	56 (46.6)	0.208
Abrasions	1 (2.8)	3 (18.9)	15 (38.5)	3 (13.6)	22 (16.3)	0.038
Total no. of cases	35 (100.0)	16 (100.0)	39 (100.0)	22 (100.0)	112(100.0)	

Fischer's exact p-value was used due to low cell count, below 5

4.5 Prevalence of skin conditions at activity spaces

Prevalence of scars at the various activity spaces is presented in table 4.4 below; 100.0%, 90.5%, 96.4% and 87.5% with respect to dismantlers, burners, collectors and sorters has scars respectively. Burners, (28.6%) presented with most rashes followed by collectors (10.7%) and dismantlers (10.5).

Generally, there were lower percentages for skin peeling; 7.9% for dismantlers and 4.8% for burners. None was recorded for collectors and sorters. Total number of cases refer to unique individuals from each activity space who responded to each category of injury and skin conditions. It could be seen from the table that with a p-value of 0.000, there is a strong association of activity space with sustaining burns. Furthermore, the prevalence of burns was higher among burners (77.3%), than sorters (11.4%), dismantlers (6.7%) and collectors (6.3%).

The same table also shows scar density among the various activity spaces. With a mean of 30.6, scar density was high among the dismantlers followed by 27.0, 21.4 and 17 for burners, sorters and collectors.

Table 4. 4: Assessment of skin conditions at activity space

Characteristic Assessed	Activity space					Statistic P-value
	Collectors	Sorters	Dismantlers	Burners	Total	
Skin conditions^b						
Scars	27 (96.4)	14 (87.5)	39 (100.0)	19 (90.5)	99 (93.6)	0.275
Rashes	3 (10.7)	3 (8.5)	4 (10.5)	6 (28.6)	16 (14.6)	0.201
Skin peeling	0	0	3 (7.9)	1 (4.8)	4 (3.9)	0.368
Total no. of cases	35 (100.0)	16(100.0)	39 (100.0)	22 (100.0)	112(100.0)	
Burns						0.000
No	30 (93.8)	14 (93.3)	31 (88.6)	5 (22.7)	80 (76.9)	
Yes	2 (6.3)	1 (6.7)	4 (11.4)	17 (77.3)	24 (23.1)	
Total	32 (100.0)	15 (100.0)	35 (100.0)	22 (100.0)	104(100.0)	
Scar density						
Number	35	16	36	22	112	
Mean	17.0	21.4	30.6	27.0	24.3	
Stand. dev	9.8	10.5	12.1	10.9	12.3	
P50	16	23	32	30	25.5	
IQR	15	14.5	13	10	18	

^b multiple responses allowed for various injuries and skin conditions. Fischer's exact p-value was used due to low cell count, below 5. Stand dev- standard deviation, P50- 50th Percentile, IQR-Intra Quartile Range

4.6 Common injuries with background characteristics

Injuries looked at were mostly cuts, lacerations and abrasions. These were looked at with respect to age, marital status, length of work and daily working hours. Cuts appeared to be the most common injuries observed. Looking at the age groups 20-29 and 30-39 years, there were 46 (80.7%) out of the total 57 respondents and 14 (82.4%) out of 17 reported cuts as compared to 12 (21.1%) and 4 (23.5%) and also 5 (8.8%) and 2 (11.8%) in the same age groups and total number of cases for lacerations and abrasions respectively as indicated in table 4.5.

It is interesting to note here that with respect to length of work, the trend was that the longer the length of years spent on the job the higher the prevalence of injuries. The trend

seen for 6-12 months, 1-5 years and more than 5 years was 10, 25 and 40 cases respectively for cuts; 2, 7 and 13 for lacerations and 2, 3 and 6 for abrasions.

There was no significant association between injuries and marital status, length of work and also daily working hours as the p-values indicate.

Table 4.5: Injuries with background characteristics

Characteristic	Injuries			Total no. of cases	P-value
	Cuts	Lacerations	Abrasions		
Age					0.250
<20	14 (77.8)	4 (22.2)	2 (11.1)	18	
20 – 29	46 (80.7)	12 (21.1)	5 (8.8)	57	
30 – 39	14 (82.4)	4 (23.5)	2 (11.8)	17	
40+	2 (33.3)	2 (33.3)	2 (33.3)	6	
Marital status					0.114
Unmarried	36 (81.8)	6 (13.6)	2 (4.6)	44	
Married	40 (74.1)	16 (29.6)	9 (16.7)	54	
Length of work					0.901
6 - 12 months	10 (83.3)	2 (16.7)	2 (16.7)	12	
1 - 5 years	25 (75.8)	7 (21.2)	3 (9.1)	33	
> 5	40 (77.3)	13 (25.0)	6 (11.5)	52	
Daily working hours					0.416
5 – 10 hours	15 (71.4)	5 (23.8)	1 (4.8)	21	
11 – 15 hours	59 (80.8)	15 (20.6)	9 (12.3)	73	

4.7 Skin conditions with background characteristics

Skin conditions considered were scars, rashes, peeling and burns. These were looked at with respect to age, marital status, length of work and daily working hours.

As shown in table 4.6, age, marital status, length of work and daily working hours had no significant association with skin conditions; age (0.139), marital status (0.140), length of work (0.138), daily working hours (0.795).

Scars appeared to be common among all the skin conditions observed. Apart from scars, there was no 100% observation of skin conditions among the study subjects with respect to age, marital status, length of work and daily working hours. Age 40+, married subjects, those who have spent 6-12 months on the job and those who work 5-10 hours daily all had a 100%

recorded observation for scars. The others, comprising of rashes and skin peeling generally had low observations for skin conditions against the characteristics of interest. As could be seen from the table 4.6, there were 10.5%, 6.8%, 0, 0, 8.7%, 3.5%, 0, 5.9%, 7.3%, 0 and 7.9% with respect to the various age categories, unmarried, married, various categories for length of work and daily working hours respectively.

Table 4.6: Skin conditions with background characteristics

Characteristic	Skin conditions			Total no. of cases	P-value
	Scars	Burns	Others ^a		
Age					0.139
<20	18 (94.7)	10 (52.6)	2 (10.5)	19	
20 – 29	58 (98.3)	13 (22.0)	4 (6.8)	59	
30 – 39	18 (100.0)	0	0	18	
40+	7 (100.0)	1 (14.3)	0	7	
Marital status					0.140
Unmarried	44 (95.7)	14 (30.4)	4 (8.7)	46	
Married	57 (100.0)	10 (17.5)	2 (3.5)	57	
Length of work					0.138
6 - 12 months	13 (100.0)	3 (23.1)	0	13	
1 - 5 years	33 (97.1)	12 (35.3)	2 (5.9)	34	
> 5	54 (98.2)	9 (16.4)	4 (7.3)	55	
Daily working hours					0.795
5 – 10 hours	23 (100.0)	5 (21.7)	0	23	
11 – 15 hours	74 (97.4)	17 (22.4)	6 (7.9)	76	

a. Rashes, skin peeling

4.8 Assessment of Systolic and Diastolic Blood Pressure

ANOVA was used to test for association of being hypertensive with activity space. From table 4.7, p-values of 0.773 and 0.887 for both mean systolic and diastolic BPs shows that there is no difference in mean systolic and diastolic BPs with respect to activity space. There was no significant difference in being hypertensive across activity space. There was no hypertensive case found among the sorters.

Table 4.7: Mean systolic and diastolic blood pressure across activity spaces

Characteristic	Activity space					P-value
	Collecting	Sorting	Dismantling	Burning	Total	
Blood pressure						
Mean systolic \pm SD	123.1 \pm 11.3	120.7 \pm 11.7	121.7 \pm 12.8	119.7 \pm 3.9	121.6 \pm 12.3	0.773
Mean diastolic \pm SD	72.8 \pm 8.7	73.1 \pm 10.5	74.1 \pm 8.7	72.4 \pm 9.5	73.2 \pm 9.0	0.887
Hypertension						
Normotensive	29 (82.9)	16 (100.0)	36 (92.3)	20 (90.9)	101 (90.2)	0.315
Hypertensive	6 (17.1)	0	3 (7.7)	2 (9.1)	11 (9.8)	
Total	35 (100.0)	16 (100.0)	39 (100.0)	22 (100.0)	112 (100.0)	

ANOVA used to test for association

Table 4.8 shows age-specific categories of blood pressure measurements, age 30-39 and 40+ had normal blood pressure, 100.0% whereas < 20 recorded 95.0% and 84.1% for age 20-29. The highest percentage of hypertension among the age categories was 15.9% for age 20-29, followed by 5.0% for < 20.

Table 4.8: Blood pressure with age Categories.

Characteristic	Age (years)				Total	P-value
	< 20	20-29	30-39	40+		
Hypertension						
Normotensive	19 (95.0)	53 (84.1)	22 (100.0)	7 (100.0)	101 (90.2)	0.131
Hypertensive	1 (5.0)	10 (15.9)	0	0	11 (9.8)	
Total	20 (100.0)	63 (100.0)	22 (100.0)	7 (100.0)	112 (100.0)	

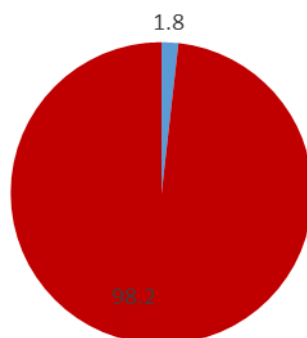
4.9 Health seeking behaviour and the desire of e-waste workers for a clinic at the dump site

Health seeking behaviour and the desire of e-waste workers for the construction of a clinic at the dumpsite is presented in table 4.9. 83.0% of the study subjects said they seek healthcare from clinic or chemical store when ill or injured. When their view on knowledge of NHIS was sought, it was seen that 94.6% knew about it, 93.8% knew that it offered healthcare at little or no cost to registered members and 44.6% of them were registered with the scheme.

Table 4.9: Health seeking behaviour and knowledge on NHIS

Characteristics	Frequency distribution		Cumulative
	Frequency	Percent	
What is done when ill or injured			
Go to the nearest clinic or chemical store	93	83.0	83.0
Tie it with a piece of cloth	6	5.3	88.4
Cover it with herb or see herbalist	6	5.4	93.8
Use a plaster	4	3.6	97.3
Just ignore it / others	3	2.7	100.0
Total	112	100.0	
NHIS knowledge			
Does not know about NHIS	6	5.4	5.4
Knows about NHIS	106	94.6	100.0
Total	112	100.0	
Knowing NHIS provides relatively free healthcare			
No	7	6.3	6.3
Yes	105	93.8	100.0
Total	112	100.0	
NHIS registration			
No NHIS registration	62	55.4	55.4
Registered for NHIS	50	44.6	100.0
Total	112	100.0	

Figure 4 gives a graphical presentation of the response given when asked as to whether the e-waste workers felt that there was a need for a first aid clinic. 98.2% representing 110 out of the 112 respondents responded in the affirmative. 1.8% thought there was no need for a clinic at the site.

**Figure 4: Need for a First Aid Clinic**

The pie chart in figure 5 below shows that 96.4% expressed the willingness to attend the clinic in order to be attended to by a doctor or nurse. 3.6% responded in the negative.

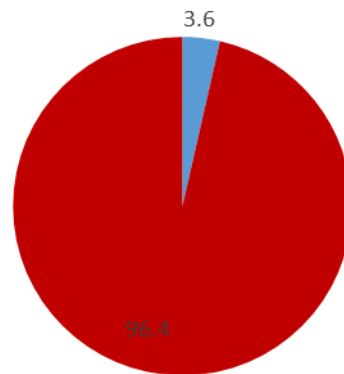


Figure 5: Willingness to attend the first aid clinic

When asked whether they were willing to pay to access health care at a first aid clinic at the site, 97.3% of the respondents responded in the affirmative. 2.7% of them were unwilling to pay. This can be clearly seen in figure 6 below.

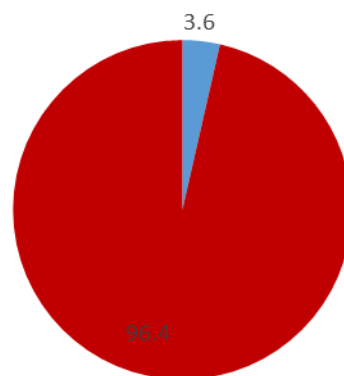


Figure 6: Willingness to pay for health care services

4.10 Use of Personal Protective Equipments (PPE)

The non-use of PPE among the study subjects was more than the usage. Table 4.10 shows that 52.7% of all the study subjects did not use PPE whereas 47.3% made use of a form of

PPE. Majority of the workers who did not use PPEs were collectors with 68.6% followed by burners, dismantlers and sorters with respective percentages of 50.0, 46.2 and 37.5.

Hand gloves (60.7%) were more favoured in terms of PPE usage as compared to safety shoes (54.9%), nose masks and overall coat (9.8%). No usage of overall coat was recorded for dismantlers and burners.

Table 4.10: PPE use and type by activity space

Characteristic	Activity space				Total	P-value
	Collecting	Sorting	Dismantling	Burning		
Use PPE						0.124
No use of PPE	24 (68.6)	6 (37.5)	18 (46.2)	11 (50.0)	59 (52.7)	
Use of PPE	11 (31.4)	10 (62.5)	21 (53.9)	11 (50.0)	53 (47.3)	
Total	35 (100.0)	16 (100.0)	39 (100.0)	22 (100.0)	112 (100.0)	
Type of PPE used*						0.029
Nose mask	1 (9.1)	1 (11.1)	1 (5.0)	2 (18.2)	5 (9.8)	
Hand gloves	3(27.3)	3 (33.3)	18 (90.0)	7 (63.6)	31 (60.7)	
Safety shoes	5 (45.5)	6 (66.7)	12 (60.0)	5 (45.5)	28 (54.9)	
Overall coat	4 (36.4)	1 (11.1)	0	0	5 (9.8)	
Total no. of workers	11 (100.0)	9 (100.0)	20 (100.0)	11 (100.0)	51 (100.0)	

* multiple response allowed

It could be seen from table 4.11 that with respect to length of work, those who have spent >5 years on the job did not make use of PPEs as indicated by 55.7% against 50.0% and 46.2 % for those who have spent 1-5 years and 6-12 months respectively. On the other side, those who have spent 6-12 months made more use of PPE than 1-5 years and >5 years as could be seen from the following corresponding percentages; 53.9, 50.0 and 45.0.

Furthermore, as indicated in table 4.11, it could also be seen that those who have worked for 6 - 12 months spent more hours (11-15 hours) working daily (84.6%) than the others who have worked for 1-5 years (75.7) and >5 years (74.1) for the same number of working hours.

Table 4.11: Personal Protective Equipment use and years of work or daily working hours

Characteristic	Length of work			Total	P-value
	6-12 months	1-5 years	>5 years		
Use PPE					0.797
No	6 (46.2)	19 (50.0)	34 (55.7)	59 (52.7)	
Yes	7 (53.9)	19 (50.0)	27 (45.0)	53 (47.3)	
Total	13 (100.0)	38 (100.0)	61 (100.0)	112 (100)	
Daily working hours					0.855
5 - 10 hours	2 (15.4%)	9 (24.3)	15 (25.9)	15 (25.9)	
11 – 15 hours	11 (84.6%)	28 (75.7)	43 (74.1)	43 (74.1)	
Total	13 (100.0)	37 (100.0)	58 (100.0)	58 (100.0)	

Users of PPEs were mainly those less than 20 years (60.0%), followed by 40+, then 20-29 and 30-39 respectively. The order of non-usage are 30 – 39 (59.1%), 20 -29 (55.6 %), 40+ (42.9%) and less than 20 years (40.0). Non-usage was higher (52.7%) than usage (47.3%) of PPE. Table 4.12 shows a display of this analysis.

Table 4.12: PPE Use Work among Age Categories

Characteristic	Age (years)				Total	P-value
	< 20	20-29	30 – 39	40+		
Use PPE						0.534
No	8 (40.0)	35 (55.6)	13 (59.1)	3 (42.9)	59 (52.7)	
Yes	12 (60.0)	28 (44.4)	9 (40.9)	4 (57.1)	53 (47.3)	
Total	20 (100.0)	63 (100.0)	22 (100.0)	7 (100.0)	112(100.0)	

CHAPTER FIVE

DISCUSSION

5.1 Overview

This study generally sought to conduct a spatial assessment and also to analyse health conditions associated with e-waste workers in different activity spaces. Specifically, mapping of different health conditions was carried out with the view to map out injuries and skin conditions that are associated with the activities of collectors, sorters, dismantlers and burners as well as to assess their systolic and diastolic blood pressure and also describe the health seeking behaviour and the desire of the e-waste workers for a first aid clinic at the Agbogbloshie dump site. The outcome of the study was to be a guide in the making of policies with respect to e-waste activities in the country by government and stakeholders.

The spatial location of the Agbogbloshie e-waste site in Accra of Greater Accra Region is $0^{\circ}13'31.966''$ W, longitudes and $5^{\circ}33'8.726''$ N, latitude (this is read as longitudinally, 0 degrees, 13 minutes and 31.966 seconds west and in latitude, 5 degrees, 33 minutes and 8.726 seconds north of Greater Accra).

By virtue of the work they do, e-waste workers are highly prone to injuries. The injuries looked at in this study were cuts, lacerations and abrasions. Chikharmane et al. (2009) reported that e-waste workers are at a higher risk of work related accidents and more likely to suffer physical injuries and physical disabilities than the general population. It could be seen from table 4.3 that all the study subjects had some forms of injuries. The most prevalent injury was cuts, as 96.2% said they had experienced it on the job. Lacerations (46.6%) and (16.3%) abrasions were reported. The higher number of cuts among the workers could be attributed to mostly working with broken WEEEs, as one could get a cut from the sharp ends even when one handles these carefully. As shown in table 4.5, the

highest number of cuts was observed among age group 20- 29 (80.7%). Most of those with lacerations and abrasions were within this same age group. This could possibly be attributed to the fact that they were many among all study subjects, they constituted 56.3% of the number (table 4.2). Among the various activity spaces, the dismantlers (94.9%) constituted the majority of the workers with cuts. This is not surprising since the dismantlers are constantly exposed to sharp objects. Similar observations have been made in workers engaged in CRT recycling. Manhart et al. (2011) and Kurian (2007) observed that for the workers who engage in recycling of CRTs, cuts and injuries from breaking of tubes are common.

It was realised from the study that the longer an e-waste worker stays on the job, the greater the risk of injuries. From table 4.5, it could be realised that for length of work, those who had spent more than 5 years on the job recorded 40 cases of cuts as compared to 25 and 10 cases for those who had spent 1-5 years and 6-12 months respectively on the job. Again, looking at lacerations, > 5 years had 13 cases whereas 1-5 years and 6-12 months saw 7 and 2 cases respectively. Similar trend could be seen for abrasions.

From the study, it was realised that non-usage of PPEs was more common in those who had spent > 5 years (55.7%) as compared to 50.0% and 46.2% for those who had spent 1-5 years and 6-12 months on the job, respectively (table 4.11). On the other hand, those who had worked for 6-12 months (53.9%) made use of PPE than 1-5 years (50.0%) and > 5 years (45.0%). This could probably explain why those who have worked for > 5 years had higher prevalence of injuries. It was more common to see injuries in and around the palms as compared to the feet. Several of the study subjects, especially the dismantlers were seen with uncountable number of cuts in and around their palms. When asked about the cause of the cuts, the common answer each and every one of them gave was “ibi scrap that cut me when working” (“I sustained the cuts from scrap metals that I work with”). Generally,

it was observed that most of the workers did not use PPE as expected. 52.7% of the workers did not use any form of PPE and the 47.3% who used a form of protection used mostly nose masks, hand gloves and heavy shoes. These were not necessarily in their recommended forms. This is in agreement with Fu et al (2011), who observed in their study that the workers work without using facial masks, goggles or protective goggles. As a result, they are prone to so many injuries which otherwise could have been minimized. In the course of the data collection, most of them came with heavy shoes and hand gloves etcetera. This is consistent with a study by Akormedi et al. (2003) where some of the workers were quoted to have said that “I use heavy shoes to protect me from cuts in my legs, I don’t use gloves, but what I do is I don’t get close to where they do the burning and in case I am passing by I use duster to cover my face, nose and eyes.”

Skin conditions considered in this study included scars, rashes, peeling and burns. Burns, as mentioned here, was not just burns sustained during burning, but also chemical burns, as a result of coming into contact with harmful substances. Scars were the most common skin conditions seen among the study subjects as can be seen from table 4.4, one can say that between the scars, rashes and skin peeling, there was a record of 93.6% for scars, followed by rashes (14.6%) and skin peeling (3.9%). Out of the four activity spaces, it could be seen that the dismantlers had the highest percentage (100.0%) of scars, followed by collectors (96.4%), burners (90.5%) and sorters (87.5%). It is not too surprising to realise that the dismantlers had higher prevalence of scars because as discussed earlier, they sustained more injuries and as the injuries heal, scars are left behind. Generally, there were lower percentages of rashes and skin peeling among the study subjects. There was no case of skin peeling among collectors and sorters. This could be due to the fact that collectors and sorters did not really come in direct contact with the harmful substances that are found within the WEEE and which irritate the skin as compared to mainly the

dismantlers and burners. Such irritating elements like mercury, nickel and beryllium are found in the e-waste materials and so whiles working on them, such as in the case of dismantling, these could spill and come into contact with the body. According to WHO, Hg may cause skin rashes, skin discoloration, scarring as well as a reduction in the skin's resistance to bacterial and fungal infections. Mercury is one of the common elements found in e-waste materials. It is found in thermostats, sensors, relays, switches commonly found on printed circuit boards, mobile phones, batteries and in flat display panels. Ideho (2012) suggested that the use of mercury is likely to increase in flat panel displays in years to come and this will further increase the risk of being exposed to mercury.

As already discussed, the majority of the workers did not use appropriate PPEs such as hand gloves, goggles, facial masks, aprons and protective footwear. In the absence of these, workers stand at a higher exposure risk to harmful elements and should this happen, the skin may react to these chemicals resulting in skin allergies, peeling, dermatitis, rashes and chemical burns. The prevalence of skin conditions among the e-waste workers at Agbogbloshie is in line with the findings of Kishore and Kishore (2010) in their study at Guiyu (famous for being among the top e-waste sites in the world) in China, where they observed that there were high incidence of skin damage among residents of Guiyu and skin diseases topped the list of the effect of e-waste activities. A previous study by Qiu et al. (2004) at the same site also observed that among the residents of Guiyu, there were high incidence of skin problems, all of which may be caused by the primitive recycling processing of e-waste. Study subjects in the age category 20 – 29 had an overall higher incidence, 59, as compared to age <20 (19), followed closely by age 30 – 39 (18%) and 7 cases for age 40+. The higher number of cases of skin conditions of those study subjects in the age category 20 – 29 could also be due to the fact that they outnumbered the other age categories. As indicated in table 4.2, 56.3% of all study subjects belonged to this age

category. Also, they constituted 55.6% of those who do not use PPEs (table 4.12). Interestingly, there was no single case of burns, rashes and skin peeling among those in age categories 30 – 39 and 40+. Among the 40+, 57.1% made use of PPE and this could be a contributory factor to the absence of some skin conditions.

In totality, a trend could be seen that the longer the number of years one works at the site, the higher the risk of exposure to skin conditions. From table 4.6, it could be seen that there were 55 cases among those who had worked for > 5 years, followed by 1 - 5 years (34) and 6 - 12 months (13). This could be attributed to the fact that the longer they stayed on the job, the higher their exposure to harmful substances found in the e-waste materials as compared to someone who had worked for some few months. Table 4.11 also showed that 55.7% of those who have worked for > 5 years did not use PPE. Non-use of PPE increased one's exposure risk for injuries. The same trend was seen with respect to daily working hours. 76 cases of those who worked for 11- 15 hours had skin conditions as opposed to the 23 cases for those who worked for 5 – 10 hours daily. The burners had the highest prevalence (77.3%) of burns followed by dismantlers with 11.4% (table 4.4). The burns experienced by the dismantlers could possibly be chemical burns. As they disassembled the WEEEs, the harmful chemicals could spill and get into contact with their bodies to cause various skin disorders, including burns. This is in agreement with the study by Aucott et al. (2003), where it was observed that mercury found within light sources could be released during the disassembling process.

Systolic and diastolic blood pressure of all study subjects were checked three consecutive times and the mean for each found. The WHO standard for diagnosing hypertension is that the mean of three consecutive readings at one visit for systolic blood pressure (SBP) should be ≥ 140 mmHg and diastolic blood pressure (DBP) should be ≥ 90 mmHg. For normotension, the SBP should be < 140 mmHg and DBP should be < 90 mmHg. Table 4.7

shows that there was no significant difference in mean SBP and DBP as well as being hypertensive across activity space. The mean SBP and DBP were all normal. None of the sorters was hypertensive. None of the study subjects had a mean blood pressure reading of $\geq 140/90$ mmHg, however, there were cases of mean SBP > 140 mmHg, the highest mean SBP and DBP reading being 157mmHg and DBP > 99.6 mmHg respectively. These are described as hypertensives throughout the results and discussion of this work. No study was found to have concluded that e-waste activities on their own cause high blood pressure during the literature review of this work. The emphasis, however, has been on the chemicals that the e-waste workers are exposed to as a result of the work they do. Among the risk factors for getting high blood pressure is exposure to certain chemicals found in WEEEs such as Hg and Lead Pb. The association between chemicals like Pb and Hg and hypertension have been documented (Allam, 2010) who suggested that Pb which is commonly found in circuit boards and cathode ray tubes causes damage to red blood cells, kidneys and also potential increases in high blood pressure. Burning of WEEEs containing lead can result in the release of the element to the air. The finding of high SBP among the study subjects is consistent with the study by Fillion et al (2006) that looked at mercury exposure and blood pressure in the Brazilian Amazon. They reported a higher risk of increased SBP among subjects with higher mercury hair levels. Also, in a study that looked at environmental exposure to Hg amongst the Nunavik Inuit tribe in Northern Quebec, Canada, Valera et al. (2009) assessed the association between Hg levels and BP, and found that there was a positive association between mercury levels and BP among adults whose diet was mainly traditional food (sea foods) and concluded that blood mercury concentrations were associated with increasing SBP after confounding factors were controlled. Azevedo and co-workers also observed that long term exposure to inorganic mercury increases vascular resistance and induces hypertension (Azevedo et al.,

2012). Collectors had a higher prevalence of hypertension with 17.1%, followed by burners with 9.1% and 7.7% for the dismantlers. Table 4.8 shows that with respect to age categories, 30-39 and 40+ had normal blood pressure, 100.0%, whereas < 20 recorded 95.0% and 84.1% for 20-29. This shows that generally there were higher percentages of normotensives across the various age categories as compared to hypertensives. The highest percentage of hypertension among the age categories was 15.9% for 20-29, followed by 5.0% for < 20. None was recorded for 30-39 and 40+. The highest percentage of hypertension 20-29 could also be due to the fact that they made up the highest percentage (56.3%) of the study subjects. It may be expected that as one ages, one gets a higher risk for hypertension (old age is a risk) for hypertension, however, it was realised in this study that there was no case of hypertension among age categories 30-39 and 40+.

As a result of various e-waste activities, the e-waste workers come into contact with various hazardous substances. These hazardous substances are found within the various WEEEs that the workers work with. These may be serious health hazards and sometimes emergency medical care is urgently needed. Throwing more light on injuries associated with e-waste activities, a United Nations (UN) Report in 2014 stated that the collection and recycling of heavy and sometimes e-waste materials with sharp edges lead to spinal injuries, cuts and infections. Due to the fact that the e-waste activities are highly hazardous in nature, making the workers highly exposed, this study also looked at the health-seeking behaviour of the e-waste workers and also sought their view on whether they felt there was a need for a first aid clinic at the Agbogbloshie dump site. Looking at the fact that the workers were exposed to injuries while working, it would have been welcoming for the workers to have an on-site first aid clinic to attend to their needs, especially when injured as suggested Shahly et al., (2014), that the range of services of worksite clinics may include occupational health such as treatment of work-related injuries. However, the

finding of this study showed that there was no first aid clinic at the site. Comparing this to the outcome of the GMS TRIANGLE Project (2013) that looked at another highly exposed work group, fishermen, the finding suggested that more than one-quarter of fishing vessels did not have first aid kits on board despite the fact that their work was dangerous enough to send one out of five fishers to a clinic or hospital as the result of a work-related injury. This underscores the fact that more often than not the safety and health of highly exposed work groups are marginalized and sometimes the workers themselves do not pay attention to their health.

The findings of Employee Health and Wellness Centres in 2011 estimated that 31% of employers with 500 or more employees utilized on-site clinics. The workers at the Agbogbloshie site outnumbered 500 but since they worked on their own and were not under one employer, it becomes quite a challenge to draw a contrast between the two findings.

The graph in figure 4 shows the response given with respect to the desire of the study subjects for a clinic at the dump site. Out of the 112, 98.2% felt there was the need for a clinic at the e-waste site. Only two of them felt there was no need for a first-aid clinic at the e-waste site. Of the 110 respondents who felt there was a need for a clinic, many of them said their work was risky and they would be glad to have a clinic closer to them so that they could be seen when they fall sick. As much as 96.4% of the respondents, as could be seen in figure 5, expressed the willingness to attend such a facility to access healthcare. Some of them said that they expected to be treated well and be given quality services should there be such a facility. The respondents who indicated their unwillingness to be at such a facility cited beliefs and issue of quality as reasons. They are quoted to have said the following: “My father is a herbalist and so I will prefer herbal treatment to hospital medicine”. “The hospitals in Accra are not good”. When asked whether they were willing

to pay a reasonable amount of money to access healthcare 97.3% (figure 6) of the respondents responded in the affirmative. To explain what was meant by a reasonable amount, they were told “for example 10 cedis for abrasion (scratch leading to tearing of the skin) or 20 cedis for avulsion (a forceful tearing or separation of one body part from another)”. Since they are prone to injuries, these examples were used to help them grasp the concept of “reasonable amount”.

Their views were also sought on the National Health Insurance Scheme (NHIS) to verify whether indeed these workers would like to access health care at a clinic even if they do not have money to pay. A majority of 94.6% said they knew about the NHIS, 93.8% of them said they knew that it allowed people to seek healthcare at little or no cost and 44.6% of them said they had registered with the scheme (Table 4.9), some were yet to renew their expired registration cards. All these perhaps give indication that if a first-aid clinic is established for them, they will patronise it and even for those who have not registered with NHIS, they will be willing to pay some amount of money to keep the facility running. Looking at their health seeking behaviour, 83.0% of them said they go to the nearest clinic or a chemical store to get treatment when sick or injured. For the rest of them tying wound with a piece of cloth, covering it with a herb or seeing a herbalist and the use of plaster are among other things that they do when injured. This response may show that because the majority of the people already seek orthodox assistance when injured or ill, they will welcome the presence of a first aid clinic very close to them. Having a first- aid clinic at the site will encourage them to report health challenges, especially when they are injured, injuries could then be treated soon enough in order to avoid infections and complications which may arise as a result of poor wound care.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

There are different e-waste processing activities that occur at defined spaces at the Agbogbloshie e-waste site. However, commonest among these activities are collecting, sorting, dismantling and burning of e-waste materials. These activity spaces were mapped out with a GPS device and a map was generated.

Collecting involves the workers going to homes, places of work, offices, industries and refuse dumps to collect discarded and out-of-use electronic gadgets. Sometimes, the collectors part with money in order to get these electronic materials. The materials are then transported to Agbogbloshie mainly in carts and sometimes in trucks. This is the main source of materials for the other e-waste activities.

At the site, the e-waste materials collected are sorted into various kinds by the sorters. These sorted goods are either sold to refurbishers who buy them, repair them where possible and resell to ready markets. Most of the time, these goods mainly find themselves in the hands of dismantlers.

Cuts were the commonest injuries that the e-waste workers were exposed to, followed by lacerations and abrasions. The dismantlers are the most exposed to injuries among the e-waste workers.

Scars were the most common skin conditions that the e-waste workers were exposed to. Again, the dismantlers had higher prevalence of scars because they sustained more injuries and as the injuries healed, scars were left behind. Generally, there were lower percentages of rashes and skin peeling among the study subjects. There was no case of skin peeling among collectors and sorters.

There was no significant difference in mean SBP and DBP as well as being hypertensive across activity space. The mean SBP and DBP were all normal. None of the sorters was hypertensive. None of the study subjects had a mean blood pressure reading of $\geq 140/90$ mmHg, however, there were cases of mean SBP > 140 mmHg and DBP > 90 mmHg and these were described as hypertensives. The highest mean SBP and DBP reading were 157 mmHg and 99.6 mmHg, respectively.

Majority of the workers sought treatment from nearby clinics and chemical stores when injured or ill. The workers felt that there was a need for a first-aid clinic at the Agbogbloshie dump site. They expressed the willingness to patronise should there be any, and pay for services.

6.2 Recommendations

Many of the workers take care of themselves and their family from the proceeds generated from these e-waste activities. Knowing the benefits derived from e-waste activities, it is unlikely that their work will come to an end anytime soon. This should rather move stakeholders to find ways and means of improving the sector. The following have been recommended based on the findings of this work to help minimize exposure of the e-waste workers to injuries, skin conditions and high blood pressure.

- ✚ The need to get a scientific way of handling e-waste activities so that the health of the workers and the environment is not curtailed.
- ✚ Educating the e-waste workers on adequate health and safety practices, specifically related to safe handling of scraps, would help protect employee health.
- ✚ They should also be made to understand the need to wear appropriate PPE and encouraged to choose leaders from among themselves who will spread the message

near and far and also serve as “police” among them. This will be a motivation for them.

- ✚ The need for their activities to be recognized by the government and other stakeholders and involving the leaders of the Accra Scrap Dealers Association in major decisions taken about them.
- ✚ Due to the highly hazardous nature of their work, there is a need for a first-aid clinic at the facility. Should such a facility be set up, arrangement should be made with the National Health Insurance Authority so that such a facility will be accredited for their services.

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APPENDICES

Appendix 1: Consent Form

Title: “Mapping of Health Conditions Associated with E-waste Activities at Agbogbloshie, Accra”

Principal investigator: Abenaa Antwiwaa Adusei

Qualification: BSc Nursing

Address: Department of Biological, Environmental and Occupational Health,

School of Public Health, University of Ghana, Legon.

General information about the research

This research is being conducted to collect data on health conditions associated with the various e-waste activities at Agbogbloshie. It seeks to find out whether the occurrence of injuries, skin disorders and increase in blood pressure at the different e-waste processing activity areas are the same or different.

The study is purely academic research which forms part of the researcher’s work for the award of a Master’s Degree in Occupational Hygiene

The study has no room for any conflict of interest.

Possible risk and discomfort

There are no risks associated with participating in this study. The procedures involved in this study are non-invasive and will not cause any discomfort to the participants.

Description of level of research burden

Study participants would be asked to fill a questionnaire which will be interpreted into a language understood by participants by a translator. There will be direct observation and

examination of participants' skin as well as the checking of the blood pressure of all participants. It is estimated that all these will take about 30-45 minutes per each participant.

Possible benefits

The information given will guide government and other stakeholders on any future interventions on e-waste management in Ghana.

Please, be informed that you are going to be given free water and an amount of 20 cedis to make up for the time you lost to participating in the study.

Confidentiality

Data security:

All data collected will be kept under lock and key. The field notes will be expanded and typed into computer files.

Plans for record keeping:

The study questionnaire and consent forms will not be labelled with names of study subjects but rather unique identification numbers.

Person responsible and phone number

The person responsible for the data storage will be Abenaa Antwiwaa Adusei, an MSc Occupational Hygiene student of the School of Public Health, University of Ghana, Legon.

Voluntary participation.

Participation in the study is entirely voluntary and that declining to enter the study will have no negative consequences.

Contacts for additional information

Please call the person responsible for this study, Abenaa Antwiwaa Adusei on 02439410147 if you have questions about the study.

Your rights as a participant

This research has been reviewed and approved by the Ghana Health Service Ethical Review Board. Please, for further clarification about your right as a participant, you may contact the Ethical Review Committee Administrator, Ms Hannah Frimpong on 0243235225 or 050704122.

Volunteer agreement

The above document describing the benefits, risks and the procedures for the research entitled “Mapping of Health Conditions Associated with E-waste Activities at Agbogloboshie, Accra” has been read and explained to me. I have been given the opportunity to ask questions and all the questions that I have asked about the research have been answered to my satisfaction.

I agree to participate as a volunteer.

Date.....

Signature or thumbprint of volunteer.....

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual. All questions were answered and the volunteer has agreed to take part in the research.

.....

Date

Signature of witness

APPENDIX 2: STUDY INSTRUMENTS

A. QUESTIONNAIRE

Identification Number:

Date:

My name is Abenaa Antwiwaa Adusei, an MSc Occupational Hygiene student at the School of Public Health, University of Ghana. I am undertaking a study on Mapping of Health Conditions Associated with E-waste Activities at Agbogbloshie.

I will be very grateful to get your honest response to all sections of the questionnaire. Please, do not hesitate to ask for clarification if you find a part quite challenging.

Thank you

Please, kindly tick the appropriate box where applicable.

Section A: Demographic Information

1. Age.....
2. Gender. Male Female
3. Marital status Single Married Divorced Co-habiting
4. What kind of work do you do here (Activity space)? Collection Sorting
Dismantling Burning
5. What is your highest level of education? Primary Junior High Secondary
 Tertiary No formal education
6. Nationality: Ghanaian Others
7. Which region of Ghana do you come from?
8. Which ethnic group do you belong to?

9. For how long have you been doing this work? 6 – 12 months 1- 5 years more than 5 years
10. How many hours do you work in a day? 5 – 10 hours 11 – 15 hours

Section B. E-Waste Activities at Agbogbloshie

11. Do you think the work you do can harm your health in any way? Yes No; if yes, please go to 12
12. How does your work harm you?
-
13. Do you use any kind of protection while working? Yes No
14. If yes to 13, please choose which applies; nose mask hand gloves overall coat, safety shoe others
15. Do you think protection is necessary? Yes No. If yes, please specify.....
-
16. Have you ever gone through any form of training as to how you can protect yourself from any kind of danger at the work place? Yes No

Section C: Determination of Prevalence of Injuries; Cuts, Lacerations, Abrasions And Avulsions

17. What kind of injuries do you usually get? Please, tick all that apply Cuts Lacerations Abrasions Avulsion (**Note to Researcher: Observe and record on observation form**).

Section D: E-Waste Activities and Skin Conditions; Scars, Skin Peeling, Rashes and Dermatitis

18. What kind of skin disorders do you usually get? Please, tick all that applies

- Rashes Scars Dermatitis Skin peeling Allergies (**Note to**

Researcher: Observe and Record on form)

19. Did you have scars before starting this work? Yes No. if yes, go to 20

20. As compared to the number of scars you had before starting this work, how will you describe the number of scars now? same doubled tripled others, please specify.....

21. What is the main reason for getting scars?

.....
.....

Section D: E-Waste Activities and High Blood Pressure

22. Do you know your regular blood pressure reading? Yes No. if yes, please go to 23

23. What is your regular blood pressure reading?

24. Have you been diagnosed of having high blood pressure?

25. If yes to 32, how long has it been? Please, specify.....

Section F: Burns

26. Does your work here involve burning of e-waste materials? Yes No

- Sometimes

27. If yes to 33, how often do you do burning daily? Once Twice Others, please specify.....

28. What e-waste materials do you usually burn and why? Please specify.....
29. Have you sustained any injuries and/ or burns or scars as a result of burning? Yes
 No. if yes, please specify.....
30. Do you think it is important to use protective clothing during burning? Yes No.
31. Give reason for your answer to 30.....
.....
32. Do you use any protective clothing during burning? Yes No
33. Which protective clothing(s) do you usually use?
34. Which protective clothing are you not using that you think will be good to use during burning?

Section G: The need for a First- Aid Clinic

35. In your opinion, do you think there is a need for a first-aid at this dump site? Yes No.
36. If no, give reason(s) for your answer to 35.....
.....
37. Will you be willing to go to a clinic to be attended to by a nurse or doctor when you get injured while working? Yes No.
38. If no to 37, why?
39. Will you be willing to pay a reasonable amount of money to access healthcare at the Clinic in case you do not have the NHIS card, for example 10 cedis for abrasion (scratch leading to tearing of the skin) or 20 cedis for avulsion (a forcible tearing or separation of one body part from another) ? Yes No.
40. Have you heard about the National Health Insurance (NHIS)? Yes No

41. Are you aware it offers free medical care for most health conditions? Yes No
42. Do you have the NHIS card? Yes No
43. What do you usually do when you get ill or get injured while working? Go to the nearest clinic/hospital/chemical shop Tie it with a piece of cloth Cover it with a herb/see a herbalist See the spiritualist Others, please specify

Blood Pressure Measurement, Injuries and Skin Conditions Observation Form

I. Blood Pressure

Table for recording blood pressure readings

BP Measurement	1st Reading (mmHg)	2nd Reading (mmHg)	3rd Reading (mmHg)	Mean Reading (mmHg)
Diastolic				
Systolic				

II. Injuries (cuts, lacerations, abrasions, avulsion)

Prevalence of Injury(ies): Yes No

Type of Injury:

Number Visible:

Any Comment.....

III. Skin Conditions (rashes, scars, burns, allergies, dermatitis, skin peeling)

Prevalence of Skin Conditions Yes No

Type of skin condition:

Description:

Any comment.....