Health and Safety Impact Assessments Among E-waste Scavengers in Nigeria

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Health and Safety Impact Assessments Among E-waste Scavengers in Nigeria

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ABSTRACT

The global increase in the use of electrical and electronic equipment has stimulated a simultaneous rise in discarded and obsolete ones which are referred to as electronic waste (e-waste). Increasing e-waste generation poses heightened challenges for low and middle-income nations such as Nigeria. The research aimed to assess health and safety awareness levels and evaluate the quality of work life among informal e-waste recyclers to enhance their occupational health, safety practices, and well-being. A quantitative methodology was adopted, utilising a survey design with multiple questionnaires in a cross-sectional approach. The research was structured into three distinct studies. Study 1 assessed scavengers existing knowledge and awareness of the impact of e-waste hazards on human health. Study 2 measured their existing controls, safety awareness, training, and safety behaviour, while Study 3 measured the quality of work life. Data was gathered from 395 recyclers across two prominent recycling sites in Lagos. Key findings reveal the recyclers limited knowledge and awareness of e-waste's health hazards, with their occupational hygiene practices falling short of acceptable standards. The result of multiple regression analysis shows that safety awareness and behaviour significantly supported the safety climate ($p- < 0.001$), indicating that an increase in safety awareness and positive behaviour will impact the overall safety climate in the workplace. Furthermore, in a mediation analysis, the perception of safety when working together shows that workplace collective efforts were found to potentially promote positive safety behaviour. In assessing the quality of work life, five distinct factors - Job satisfaction, general well-being, occupational stress, work environment, and home-work balance emerged. Job satisfaction is overwhelmingly identified by recyclers as the most impactful on their work life. Through this comprehensive exploration, the study highlights the need to promote health and safety awareness and improve occupational hygiene practices and the work environment for informal e-waste recyclers in Nigeria.

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List of Abbreviations

AU	African Union
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
FEPA	Federal Environmental Protection Agency
ILO	International Labour Organization
ITU	International Telecommunication Union
LAWMA	Lagos Waste Management Authority
LMICS	Low- and Middle-Income Countries
NESREA	National Environmental Standards and Regulations Enforcement Agency
OSHA	Occupational Safety and Health Administration
SDGs	Sustainable Development Goals
StEP	Solving the E-waste Problem
UEEE	Used Electrical and Electronic Equipment
UN	United Nations
UNEP	United Nations Environment Programme
UPR	Ultimate producer responsibility
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization

1.0 CHAPTER ONE: INTRODUCTION

1.1 Background

Demographic growth, increasing urbanisation and technological advances are causing profound social and environmental changes which adversely affect human health. Effective waste management is a component of promoting sustainable environmental health initiatives (Park, 2015). The global electronic and electrical waste stream is expected to grow to reach 3.40 billion tonnes by 2050, and the total quantity of waste generated in low-income countries is likely to see over a threefold increase by this year (Kaza et al., 2018). Inadequate disposal and management of electronic and electrical waste can pose safety, health, and environmental concerns to both the waste handlers and the public at large. Electronic waste has become the fastest-growing flow of solid waste, especially in low and middle-income countries (LMICs) like Nigeria, but its poor management is of significant occupational health and safety, and environmental concern (Herat, 2008). Despite national and international regulatory bodies' efforts to develop electronic and electrical waste management policies, its effective management remains an issue, especially concerning its disposal and management (Mmereki et al. 2015).

Electronic and electrical waste (e-waste) is also known as Waste Electrical and Electronic Equipment (WEEE) according to the European Community Directives (European Union, 2012). As there are different terms used for e-waste, are also definitions, this means that there is yet to be an ascribed standard definition. Among various definitions is the Solving the E-waste Problem (StEP) definition: “e-waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention to re-use” (StEP, 2014:4-5). The StEp definition is encompassing and there will be no need to consider any other regional definition or any form of variances used in describing electronic and electrical waste in this study.

The categorisation of electronic waste involves classifying electronic and electrical devices and equipment based on their various characteristics, components, or compositions. This usually varies based on regions and regulations requirements. They are classified by product type, hazard, material, and functional classifications (Balde et al., 2017; European Union,

2012; Step Initiative, 2014; Kumar et al., 2017). The broadly established categorisation according to Global E-waste Monitor 2017, Step 2019 comprises six categories(Table 1.1).

Table 1.1: E-waste Categorisation (Source: Global E-waste Monitor, Balde et al. 2017: online)

Categorisation	**Examples**
Temperature Exchange Equipment	Temperature exchange equipment, more commonly referred to as cooling and freezing equipment: refrigerators, freezers, air conditioners, heat pumps
Screens and Monitors	Television, monitors, laptops, notebooks and tablets
Lamps	Fluorescent lamps, high-intensity discharge lamps, LED lamps
Large Equipment	Washing machines, clothes dryers, dish-washing machines, electric stoves, large printing machines, copying equipment, photovoltaic panels
Small Equipment	Vacuum cleaners, microwaves, ventilation equipment, toasters, electric kettles, electric shavers, scales, calculators, radio sets, video cameras, electrical and electronic toys, small electrical and electronic tools, small medical devices, small monitoring and control instruments.
Small IT and telecommunication equipment	Mobile phones, Global Positioning Systems (GPS), pocket calculators, routers, personal computers, printers, telephones

1.1.2 **Health and safety implications of Informal e-waste recycling activities**

Electronic waste remains a considerable contaminant in the environment and a risk to human health and safety. Many studies consistently report a close and strong association between exposure to heavy metals and adverse health effects (Grant et al., 2013). Mostly children represent a demographic that is inherently more vulnerable to the adverse effects accelerated by exposure to e-waste heavy metals due to their physiological systems (Grant et al., 2013; Yang et al., 2017; Adam et al., 2021; Alabi et al., 2021). Developmental neurotoxins that include lead, mercury, cadmium, chromium and Polybrominated diphenyl ethers (PBDEs) present in e-waste can impair both adults and children IQ and cognitive functions among others (Chen et al., 2011). The health effects of exposure to these substances are dependent on factors such as type of chemical, form, dose, exposure duration and root of entry. High-level exposure to cadmium for instance over a short period can result in fever and muscle pain and lung damage while low-level exposure over a protracted period can lead to chronic

diseases such as lung disease and cancer (Grant et al., 2013; Igharo et al., 2016; Wittisiepe et al., 2017). Hazardous substances in e-waste can lead to chemical poisoning if directly exposed to or when such pollutants are released into the environment. Orisakwe et al. (2019) affirmed the presence of e-waste contaminants in environmental media and living organisms in close proximity to e-waste handling sites, is a precursor to a wider population risk of exposure to e-waste harmful substances.

On this note, Forti et al. (2020) argued that e-waste should be formally collected and managed at a specialised treatment plant to help recover valuable materials while hazardous substances are controlled to prevent their escape. The lack of capable integral recycling infrastructure in Nigeria to manage e-waste is the basis for relying on informal sectors using primitive dismantling and recycling methods that include open burning of cables to extract copper wire and indiscriminate disposal of e-waste at dumpsites which are causing hazards to the environment and human (Nnorom and Odeyingbo 2019)**.** One of the biggest safety concerns when recycling e-waste is the risk of fire and explosion. Improper handling and storage of electronic waste can lead to the formation of flammable gases and chemicals, raising the risk of fire and explosion (Defraa, 2006). Fires at e-waste recycling facilities can spread quickly, causing significant property damage and posing a hazard to surrounding communities. This shortage of suitable disposal and e-waste management facilities and recycling championed by informal settings all constitute risks to the environment and human health.

While this persists, a lack of knowledge about the associated health hazards of e-waste to both the environment and humans among the handlers is of concern. A study by Ohajinwa et al. (2017) found that a good number of e-waste workers interviewed were unable to associate listed chemical substances present in the e-waste. In addition, scavengers are seen as at risk of injuries and exposure to hazardous substances associated with work performed during the collection and extraction of useable materials where personal safety is not prioritised in the entire process (Burns et al., 2019).

Numerous life-threatening environmental and occupational health cases have received increased awareness. However, crude recycling activities that are undertaken by these scavengers either at collection sites or in a designated workplace present health, safety, and environmental issues that need careful assessment and consideration, particularly in

developing countries such as Nigeria where its use and management is still an issue. Worthy of note as well is how communicable diseases continue to dominate the burden of disease in Nigeria. The demographic transition within the country has led to an increased prevalence of non-communicable diseases (NCDs) to which e-waste health impacts and other related respiratory diseases are on the increase (Obaseki et al., 2016). Because of the growing global challenges posed by NCDs the United Nations Sustainable Development Goal 3 (UN SDG 3) is one of the Sustainable Development Goals which is part of the Agenda for Sustainable Development, has set its priority to reduce premature death associated with NCDs by 30% by 2030. Specifically included in the Goal's targets is to significantly reduce the number of deaths and illnesses from hazardous chemicals and water, air and soil pollution and contamination. Therefore, the promotion of sustainable e-waste management will advance the attainment of these goals in Nigeria. Relative to the UN SDG in the promotion of sustainable environment and human health is the African Union Agenda 2063 Goals with priorities areas that include the promotion of environmentally sustainable and climate-resilient economies and communities, a high standard of living, quality of life and well-being for all citizens (African Union, 2013).

Although policy frameworks exist to protect vulnerable populations, they are not effectively applied (Forti et al., 2020). An earlier study by Ohanjinwa et al. (2017), raised concerns that are related to insufficient attention and data on informal e-waste workers' awareness and risks inherent in crude recycling of e-waste and their workplace conditions. This poses a challenge to policymakers to design tailored sustainable e-waste management plans (Popoola et al., 2019; Abalansa et al., 2021). The potential adverse health impacts from e-waste exposure, particularly within informal settings, remain unknown and unrecognised. A large segment of the general population, including the scavengers directly involved with e-waste suffer from this knowledge deficiency. This gap can be understood through the lens of the Health Belief Model (HBM), which theorises that individuals' actions toward potential health threats are influenced by their perceived vulnerability to and the perceived severity of those threats (Rosenstock, 1974). In this context, many scavengers may not be fully aware of the imminent health risks associated with e-waste due to an inadequate understanding of the health, safety and environmental consequences. Heightening this, the Social Identity Theory (SIT) provides insights into how individuals' behaviours are shaped by their perceived

membership within certain social groups (Taijfel and Turner 1986). E-waste scavengers, recognising themselves as part of a distinct group in the informal recycling sector, may develop collective norms and practices. Evaluating the safety perception and the proactive measures undertaken by recyclers to collectively establish and maintain a secure workplace is of considerable significance. While these practices offer a sense of identity and belonging, they might inadvertently heighten their exposure to health risks. Given these dual dimensions of individual health perceptions (informed by HBM) and group dynamics (informed by SIT), there emerges a pressing need to foster and embed positive environmental, health, and safety behaviour during e-waste recycling. These two theories, HBM and SIT, thus underpin the conceptual framework of this study, guiding the exploration and understanding of the relationship between individual health beliefs and collective group behaviour. Integrating these theories offers an approach to understanding the behaviour and perceptions of the scavengers. The availability of research data will stimulate policy realignment and engage relevant stakeholders towards capacity building aimed at improving workplace safety and health and preventing potential hazards and exposure inherent to improperly managed e-waste in Nigeria.

Hence, the present study aimed to assess the existing health and safety knowledge, awareness of hazard exposure, precautions and personal safety practices adopted by e-waste handlers.

1.2 Statement of the problem.

E-waste is now a crucial problem as they are now found in large amounts in landfills and recycling activities precipitate toxic substances and gases that have frightening effects on human health and Safety. Typically, informal collectors equally called scavengers operate the e-waste collection and recycling tasks in Nigeria. It is typically difficult to draw a clear distinction between collectors and recyclers as many recyclers are equally involved in the collection of e-waste (Perkins et al., 2014). Therefore, with reference to the present study, both informal collectors and informal recyclers are also referred to as e-waste scavengers.

Many scavengers suffer from non-communicable diseases (skin disorders, reproductive issues, respiratory disorders, cancer, hypertension and heart diseases among others) due to exposure to harmful substances in e-waste. The stress of manual labour, combined with the

potential exposure to toxins, can increase the risk of cardiovascular diseases (Burns et al., 2016; Popoola et al., 2019). Exposure can also result in reproductive health issues, such as decreased fertility and developmental problems in children (Grant et al., 2013; Awasthi et al., 2018; Adam et al., 2021). The physical demands of informal recycling, especially when PPE is not used, can lead to injuries and musculoskeletal problems (Ohajinwa et al., 2019; Burns et al., 2019). However, many informal e-waste recyclers often avoid seeking medical intervention because they are unaware of the seriousness of the illness. Some reported the unaffordable formal healthcare, resorting instead to painkillers or incorrectly attributing their health issues to malaria (Asampong et al., 2015). Global response to communicable diseases deserves the same intensity for non-communicable diseases, to achieve SDG 3 which is to ensure healthy lives and promote well-being for all. The potential adverse health impacts are mostly unknown and not recognised due to a lack of knowledge and awareness by most of the population and especially the scavengers who interface with e-waste at their workplace. E-waste inadequately disposed of by the local municipal waste collection services at landfill sites puts children at risk of developing health conditions due to exposure to hazardous substances released into the immediate environment or hazardous substances ingested by breastfeeding mothers (Forti et al., 2020; Orisakwe et al.,2019). Although policy frameworks to protect vulnerable population exists, they are not effectively applied (Forti et al., 2020). Ohanjinwa et al. (2017), reported the insufficient attention and data on informal e-waste workers' awareness of the health and safety risks inherent in crude recycling of e-waste and their workplace conditions and this poses a challenge to policymakers to design tailored sustainable e-waste management plans (Popoola et al., 2019; Abalansa et al., 2021). The increasing human population size has influenced the generation of waste globally particularly the increase in e-waste due to rapid technological development which now requires the need for an upgrade in general waste management as required by SDG 11. To achieve specific SDG 8 targets that include the promotion of a safe and secure working environment for all workers, it is pertinent to raise the level of awareness and knowledge to improve safety practices among scavengers. Promoting safety and health-enhancing practices among this group of workers is of paramount importance within their workplace. Accordingly, an understanding of the current level of knowledge and awareness is therefore crucial.

1.3 Significance of the study.

The study will assess the health and safety impact of e-waste handling among scavengers and review the knowledge, awareness, and practice (KAP) associated with the adverse health impact of hazardous substances related to improper handling of e-waste and the vulnerability of scavengers when exposed to the hazardous substance of e-waste.

Adding to the health risks associated with the informal recycling of e-waste, workers and surrounding communities are also at risk of physical hazards and safety concerns such as the risks of falls and other injuries. The general safety climate at e-waste recycling sites is an indicator that dictates the safety behaviour, awareness and competencies of e-waste recyclers. Furthermore, evidence of the job contentment of scavengers, stress and working conditions linked to their general well-being will be sought. The outcome of the study will help to advance the promotion and adoption of positive environmental, health and safety behaviour across the e-waste stream.

Findings from the study are envisaged to help stimulate policy realignment and engage relevant stakeholders towards capacity building intended to improve workplace safety, health and well-being, including the prevention of potential hazards and exposure inherent to improperly managed e-waste in Nigeria. In addition, the study outcome will contribute to increasing business knowledge in the existing e-waste management settings, especially in Low and Middle-Income Countries (LMICs). The study design aligns with sustainable development goals- SDGs 3, 8, and 11.

1.4 Aim and objectives.

The aim of the research is to assess health and safety awareness levels and evaluate the quality of work life among informal e-waste recyclers to enhance their occupational health, safety practices, and well-being.

1.4.1 Objectives

i. To measure scavengers' knowledge and awareness of the impact of e-waste hazardous substances on human health
ii. To measure the relationship between educational attainment and the level of safety and health practices adopted among the e-waste handlers.

iii. To assess existing control methods and safety behaviour adopted towards the management of hazardous substance exposure among the scavengers.

iv. To assess the quality of working life (job contentment, work condition, general wellbeing) among e-waste scavengers.

v. To assist in the development of measures to promote safety and health policy, and workplace safety awareness in the management of e-waste among informal workers.

1.4.2 Research Questions.

The study aimed to answer the following research questions:

1. What are scavengers' levels of awareness and knowledge of the impact of e-waste hazards on human health?
2. How does education attainment affect the level of knowledge and awareness of e-waste- hazards among scavengers?
3. What are the factors influencing safety climate among informal e-waste recyclers?
4. What factors can improve the quality of working life among e-waste scavengers?

1.4.3 Research Hypotheses.

In addition to the research questions stated above, a set of hypotheses was tested to further investigate the specific research questions identified in the study. This is to provide empirical evidence to explain and predict potential interconnections nature among the variables considered in this study.

H1: Safety training types received will significantly influence the knowledge level among scavengers regarding the impact of e-waste hazards on human health.

H2: Education attainments will impact the level of knowledge and awareness of e-waste hazards among e-waste recyclers.

H3: Safety awareness and safety behaviour among e-waste recyclers have an impact on the safety climate in the workplace.

H4: There is a significant association between collective efforts in the workplace and positive safety behaviour among e-waste recyclers.

H5: There is a significant relationship between income level and quality of work life among informal e-waste recyclers.

1.5 Scope of Research.

In understanding the occupational challenges and hazards faced by informal e-waste recyclers in Nigeria, this study seeks to examine their health and safety awareness, knowledge, practices and assess the overall quality of their work life. The study focused predominantly on Nigeria but targeted the city known for significant e-waste recycling activities. Lagos State stands as Nigeria's central hub for commerce and industry, featuring the nation's highest population density. Serving as a key port city, it is responsible for an estimated 70% of Nigeria's total cargo freight (Lagos State Government, 2020). Furthermore, Odeyingbo et al. (2017) have identified the two ports within Lagos as the primary gateways for the importation of Used Electrical Electronic Equipment (UEEE) into Nigeria. The participants in this research are informal e-waste recyclers and are also referred to as scavengers. They usually function outside the formal organisational structures, operate unregulated work standards, and bear the burden of occupational hazards. The study examined the level of the scavengers' knowledge and awareness of associated hazards and health risks related to their work activities based on quantitative research methods and specifically survey design. Three sets of questionnaires were distributed that informed the study outcome. The study obtained an in-depth understanding of the existing health and safety knowledge and awareness among e-waste scavengers in Nigeria. It provided insights into the quality of work life, thereby spotlighting the factors that largely influence them. The study is envisaged to produce evidence-based recommendations that could inform interventions, training modules, and policies that will help strengthen occupational health, safety practices, and overall working experience of informal e-waste recyclers in Nigeria. However, the informal nature of their occupation may result in the omission of certain distinct details, such as records of hours worked, incidence occurrences, and accurate income earned.

1.6 Thesis Structure.

Chapter One: Introduction.

The first chapter introduces the research topic, exploring its relevance, importance and detailing the research problem. The aim, objectives, and research questions of the study, along with the hypotheses, are comprehensively stated. The scope of the study is defined, and the structure of the succeeding thesis chapters is outlined. Furthermore, this chapter highlights the significance of studying health and safety impacts among e-waste scavengers, especially in the context of informal recycling practices.

Chapter Two: Literature Review.

The second chapter outlines the conceptual framework, which forms the backbone of this study. The pieces of literature are derived from the in-depth review of resources including academic journal articles, government reports, policy documents, factsheets, and repositories. The chapter covers existing institutional e-waste health and safety policies in Nigeria and selected low and middle-income countries. It underscores the necessity for effective e-waste management and connects it with the targets set by United Nations Sustainable Development Goals 3, 8, and 11. The chapter also identifies the research gap concerning the health, safety, and occupational impact of informal e-waste recycling, setting the background understanding for the present study.

Chapter Three: Research Methodology.

This chapter lays down the research design, elaborating on the chosen approach and the philosophical underpinnings of the study. It details the methods of data collection and the procedures followed, as well as the sampling strategy. The chapter also covers data analysis techniques for the quantitative data collected across 3 different studies. It discusses the reliability validity and ethical considerations of the study.

Chapter Four: Results and Analysis.

The fourth chapter showcases the results obtained from the research and offers a comprehensive analysis of the collected data to address the research questions and hypotheses. It includes descriptive statistics and summaries, and a range of statistical tests, such as Kruskal Wallis, regression analysis, factor analysis, and mediation analysis employed to analyse and interpret the data obtained.

Chapter Five: Discussion

This chapter provides the discussion and interpretation of the results, highlighting the implications and how they contribute to the study area. The strengths, significance, and limitations that might have influenced the validity of the findings are discussed, with areas for further research being identified.

Chapter Six: Conclusion and Recommendations.

The final chapter concludes the research study by summarising the key findings, discussing the implications and suggesting future research directions. It emphasises the contribution of the study to the existing body of knowledge on health and safety impacts among e-waste scavengers and the importance of promoting safer practices in informal e-waste recycling.

2.0 CHAPTER TWO: REVIEW OF LITERATURE.

2.1 Conceptual Framework.

A theoretical framework has been described by Grant and Osanloo (2014) as a "blueprint" for inquiry. It is a structure that guides research by adopting an existing proving theory or theories. Furthermore, the authors stated that theoretical frameworks are sometimes called conceptual frameworks, however, the terms are entirely different. Theoretical frameworks inform conceptual frameworks in a study (Grant and Osanloo, 2015). The conceptual framework of a study refers to a comprehensive structure comprising concepts, perceptions, assumptions, expectations, beliefs, and theories that underpin and guide the research based on the researcher's understanding. (Miles and Huberman, 1994; Maxwell, 2005; Grant and Osanloo, 2015). It serves as a conceptual model representing the subject of study and the factors influencing it, offering a preliminary understanding of the phenomena being investigated (Grant and Osanloo, 2015). To support the research problem of the study a conceptual framework was adopted to express the interconnectivity of the variables in this study. The Health Belief Model (HBM) and Social Identity Theory (SIT) have been integrated as the conceptual model for this research.

The Health Belief Model according to Rosenstock (1974), is based on the construct which was advanced to describe health-related behaviours that people's perception of the consequences and the likelihood of them acquiring a disease or given health condition is dependent on the knowledge of the causes and nature of the health condition (Jones et al., 2015). The Model forecasts that higher realised threats could improve the chances of adopting behaviours that promote health. Motivation to prioritise one's health is likely to be stimulated by intrinsic or extrinsic or intrinsic. Cue to actions could also be triggered by accessing information, personal experiences and awareness (see Figure 2.1). Therefore, the creation of knowledge and awareness is a trigger necessary for prompting actions that will improve health and well-being (Carpenter, 2019). Lindsay and Strathman (1997), adopted the HBM to study people's recycling behaviour and the findings of their study associated perceived threats, the likelihood of negative consequences, and self-efficacy to positively influence recycling behaviour (Rahu and Rodrigues, 2020).

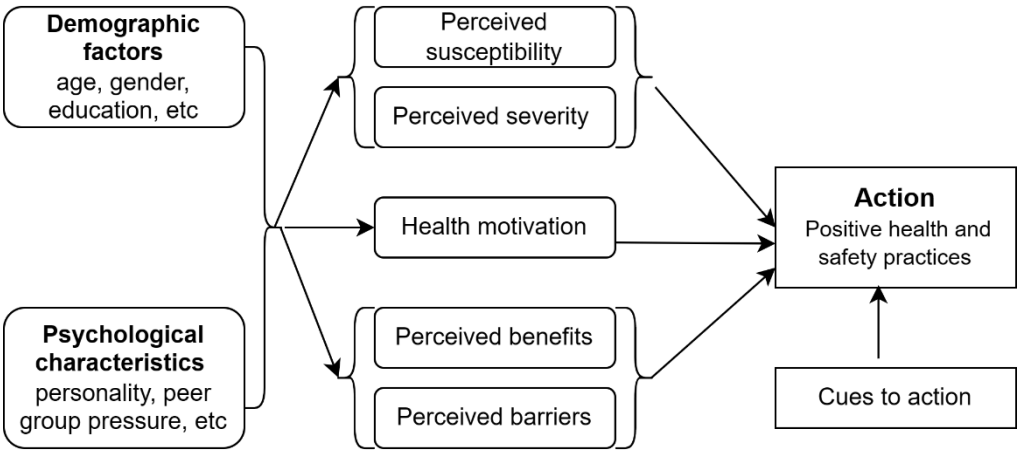

Figure 2.1: The Health Belief Model. (Source: Abraham and Sheeran, 2015)

The social identity theory (SIT) focuses on how individuals' self-concept and group identity influence their attitudes and behaviours (Taijfel and Turner 1986). It suggests that individuals derive their confidence and security from the social groups they belong to and that they conform to the norms and values of those groups. In an earlier exploration of SIT, Reicher et al. (2010) noted that large group members can structure their behaviour positively due to shared norms values and understanding. The standpoint here is that positive workplace health and safety promotion can be channelled through group norms when enhanced with workplace health and safety promotional programmes and supported by policy (see Figure 2.2).

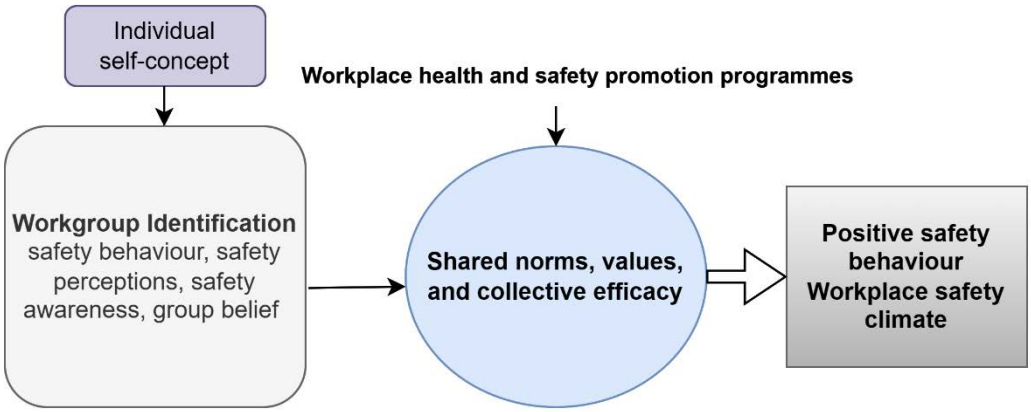

Figure 2.2: Social Identity Theory (Based on Taijfel and Turner, 1986; Haslam et al., 2009)

SIT in this framework will underpin how individuals' social identities and group affiliations influence their attitudes and behaviours. Group associations and affiliations can influence health outcomes and adherence to health and safety rules and procedures (Haslam et al., 2009). Integrating SIT into the conceptual framework will enable the exploration of how informal e-waste recyclers' individuals' social identities, group affiliations and collective efforts influence their attitudes and behaviours towards e-waste recycling and sustainable practices.

Informal e-waste recyclers are a segment of the informal sector they are exposed to various health and safety risks ascribable to the hazardous nature of e-waste, which contains toxic substances. Earlier Saphore et al. (2012), identified that recycling behaviours are influenced by collective values and individual subjective norms about knowledge and views about the environmental impacts. Asampong et al. (2015), employed the Health Belief Model as a theoretical framework to explain the findings of their study. The study investigates the correlation between the beliefs and behaviours of e-waste workers concerning their health and safety. The non-usage of the proper protective equipment and lack of knowledge and awareness of the potential health risks linked with their work. Therefore, the measure of the level of knowledge, awareness and practices will give an insight into existing occupational health and safety conditions among the group. Likewise, the understanding of the shared group norms, values and practices will provide additional insight into the group beliefs and how they can influence the adoption of positive workplace health and safety behaviour.

2.1.2 Key variables outlined in the conceptual framework.

Workgroup identification: How strongly do individuals identify with their informal e-waste recycling group and how does this identification impact their health and safety behaviour and sense of belonging in the workplace? The extent to which workers perceive support from colleagues affects their job satisfaction and work engagement. Additionally, collective efforts where achieving high-level safety is enhanced by group practices can be the output of a strong workgroup.

Norms and values: Shared norms and values within an informal recycling community can influence workers attitudes towards safety and the general workplace safety climate. This group needs to be aware of and equipped with appropriate health and safety behaviours in their workplace through supportive programmes.

Perceived susceptibility: Informal e-waste workers' beliefs about their vulnerability to health risks and hazards associated with e-waste recycling activities. Knowledge and awareness of hazardous substances in e-waste are key to understanding the susceptibility of hazards in the crude recycling of e-waste.

Perceived severity: Workers' perception of the severity and potential impact of health effects and safety issues related to informal e-waste recycling on their well-being and the environment.

Perceived benefits: The recognition of positive outcomes of adopting positive health and safety behaviours in the workplace.

Perceived barriers: Identifying the obstacles and challenges informal e-waste workers may face in adopting healthy practices that impact their well-being.

Integrating SIT and HBM into this study of informal e-waste workers provides a perspective that considers both social and health-related aspects of their work environment. The conceptual framework allows the researcher to explore the interplay between social identity, health beliefs, and Quality of Work Life (QoWL), leading to a further understanding of the factors influencing the well-being and health-related behaviours of informal e-waste workers. Individuals' beliefs about the importance of maintaining good health and taking preventive measures (HBM) may also influence their behaviour in the workplace, leading to better work-life balance and overall QoWL. These insights can inform the development of targeted interventions and policies aimed at improving overall QoWL and health outcomes in this unique work setting. The conceptual framework is presented diagrammatically below. Figure 2.3.

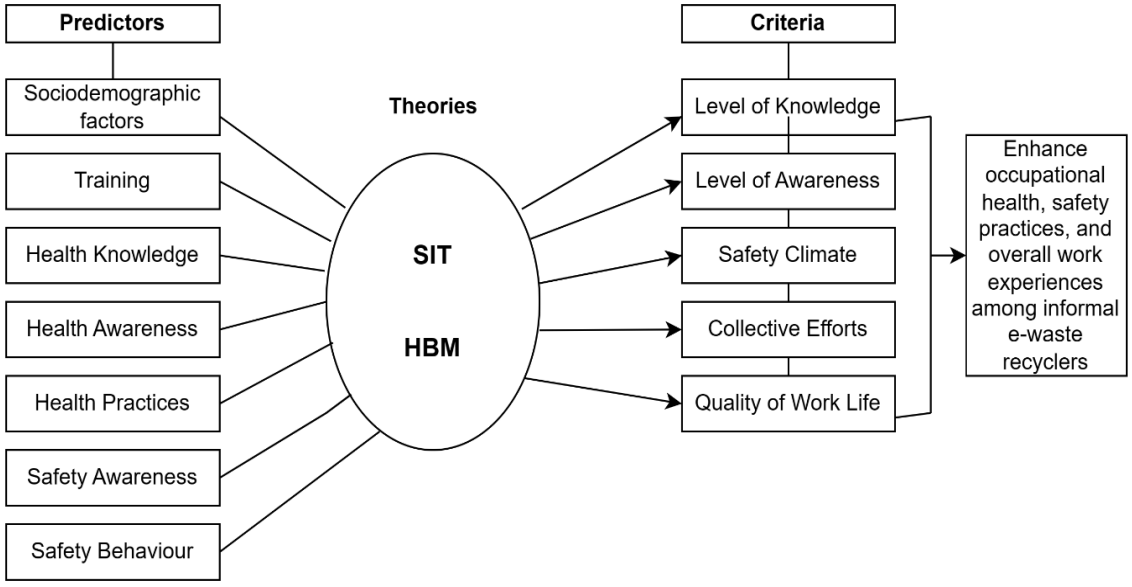

Figure 2.3: Conceptual Framework model diagram

2.2 The Review of existing institutional e-waste safety and health policies in Nigeria and selected low and middle-income countries (LMICs).

International trade in hazardous waste which includes e-waste has trended for decades and as a result led to increased environmental and human health problems (Lundgren, 2012; Adediran & Abdulkarim, 2012; Daum et al., 2017). LMICs are those countries with low-income or middle-income economies that are not high-income economies according to the World Bank (2022) Classification. In the wake of this, an international agreement was formed at the Basel Convention on the control of the transboundary movement of hazardous waste and their disposal in 1989 (Basel Convention) as a United Nations Environmental Program response to the issues of e-waste dump in parts of the world mostly LMICs (Kumar 2017; Bimir, 2020). According to the records, the convention has 188 parties (Basel Convention). As reported by the Basel Convention (2019), the Basel Convention aims to "protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements and disposal of hazardous and other wastes". Additional related international conventions such as the Rotterdam Convention (1998) and the Stockholm Convention (2001) were established (Lundgren, 2012). In a similar stride, the necessity for regional conventions was considered and the Bamako Convention on the ban of hazardous waste importation into Africa was signed in Bamako and became effective in 1998

(Lundgren, 2012; Abalansa et al., 2021). To strengthen further the continent's commitment as contained in the Bamako convention, other commitments were reached that include; The Durban declaration in 2008- towards commitment to sustainable e-waste management, having each country define a roadmap to specific projects relating to e-waste management in solving the e-waste problem, Nairobi Ministerial declaration in 2006 (conference of the Parties to the Basel Convention, emphasized on the promotion and awareness at all level of the issue of e-waste and in support of Basel Convention as the main global instrument guiding the environmental sound management of hazardous e-waste) and Libreville declaration in 2008 on health and environmental strategic alliance among African Countries to protect the population from health threats relating to the environment including accession to and implementation of Bamako convention (Abalansa et al., 2021; UNEMG, 2017).

In addition to international and regional proclamations, some LMICs have put in place national regulations controlling the increasing e-waste amassments in efforts to curb associated negative impacts (Odeyingbo et al., 2017; Forti et al., 2020; Bimir, 2020). Despite the existence of e-waste legislation at both international, regional and national levels illegitimate e-waste transport is persistent in most developing economies, (UNEMG, 2017), this may be attributed to lax implementation of existing institutional policies and legislation (Lundgren, 2012; Mmereki et al., 2016; Odeyingbo et al., 2017; Maphosa and Maphosa 2020). In Nigeria, imports of Used Electrical and Electronic Equipment into the country are inevitable as they serve as a means of providing the country's population with electric and electronic equipment at a low cost (Freiburg et al., 2011). There is no doubt that the affordability of these items at a low price has enabled the widespread use of information and communication technologies toward bridging the digital divide and prompted the technological development seen to date (Oteng-Ababio, 2012; Odeyingbo et al., 2017; Bimir, 2020).

2.2.1 The state of e-waste management in Nigeria.

Nigeria's Federal Environmental Protection Agency (FEPA) was established in 1988 shortly after the incidence of toxic chemical waste dumped in Koko in Southern Nigeria (Environment.gov.ng 2021). The establishment of FEPA was considered a milestone in the environmental management initiatives of the nation. At the time as part of FEPA duties, the agency is to provide national guidelines, and standards around the management and protection of the environment, which includes the management of general waste streams

and other forms of pollutants. However, over time, FEPA was absorbed into the structures of the Federal Ministry of Environment in 1999 (NESREA 2007, Environment.gov.ng 2021). In 2007, National Environmental Standard and Regulations Enforcement Agency was established and charged with the task of protecting and developing the environment including the enforcement of environmental regulations, rules, laws, policies and guidelines (NESREA 2007). A further step was taken by the agency in 2011 to include regulations on new and used electrical and electronic items, the regulation is referred to as the National Environmental (Electrical and Electronic, Sector) Regulations, 2011. These regulations are entrenched in the principle of the 5Rs (Reduce, Repair, Re-use, Recycle and Recover) along with a life cycle approach that covers all aspects of the electrical and electronic sector from cradle to grave (NESREA, 2011).

Nigeria is one of the main destinations for e-waste (Lundgren, 2012; Odeyingbo et al., 2019; Bimir, 2020) and consumers, dismantlers and recyclers are culpable for e-waste open dumping, open burning and acid baths which eventually affect the environment and human health (Bimir, 2020; Abalansa et al., 2021). While policies and regulations to guide and support the management of e-waste exist with empirical evidence stated in (FEPA 1999; NESREA 2007, 2009, 2011), electronic waste is still poorly managed. The need for an appropriate collection of waste is an important step in the management of e-waste, considering the process will provide categorisation and transfer of e-waste streams to the required treatment facility (Wang et al., 2012). However, the disposal of e-waste alongside other domestic waste is still widely practised in most LMICs like Nigeria (Mmereki et al., 2015;). The collection method of e-waste in the country is largely informal and mostly undertaken by scavengers (Lundgren, 2012; Ogungbuyi et al., 2012; ILO, 2019). Okorhi et al. (2017), reported in their study of e-waste strategies in Southeastern Nigeria that the process of e-waste management should differ from the ones adopted for municipal solid waste given the potential hazards e-waste presents.

While states within the country have departments responsible for waste management, however, their focus is on the collection of municipal and industrial waste (LAWMA 2021), leaving other waste stream management partly in the hands of individuals which mostly goes unmonitored. The recycling process of e-waste is mostly dominated by informal processing. Institutional health and safety guidelines in existing policies in Nigeria communicated

extensively on formal settings but no emphasis on informal settings (Ohajinwa et al., 2017). Ohanjinwa et al. (2017), opined that although health and safety risks are inherent within the formal and informal work environments. However, there are established health and safety procedures and guidelines within the formal work setting to help curtail exposure to health risks in the workplace (ILO, 2012). On the other hand, informal work environments lack health and safety guidelines which could be attributed to the disregard for informal settings when policies and guidelines are being formulated. Since the recycling sector is dominated by informal settings, this creates difficulties in implementing government policies and regulations (Ohajinwa et al., 2017).

2.2.2 Assessment of e-waste management in Ghana.

Ghana is a signatory to the Basel Convention and Bamako Convention (Oteng-Ababio, 2012) with the aim of controlling the proliferation of toxic waste in the country. Daum et al. (2017) opined that while there exists general environmental legislation in Ghana, the country lacks specific policies on the management of e-waste. However, the year 2012 saw the introduction of the electronic waste-related bill called "The Hazardous and Electronic Waste Control and Management Bill" which was initiated to keep track and towards sustainable management of the inflow of e-waste in Ghana and finally ratified in 2016 as Presidential Decree –Act 917/2016 (Daum et al., 2017). This Act tasked the Environmental Protection Agency to take preventive measures, maintain the database, and ensure adequate recovery and disposal. The Act also institute an eco-levy on the import of used electronic electrical equipment to be paid by importers and distributors of EEE and UEEE (ITU, 2021). Despite the introduction of the electronic waste management bill, e-waste in Ghana is largely managed by the informal sector where electronic waste collection and recycling activities are left open to unskilled workers (Abalansa et al., 2021). Collecting e-waste door-to-door, where scavengers offer fees to the owners and later sell the collected items to e-waste traders, is a widespread practice in Ghana (Tetteh, 2018). Electronic waste handling procedures in Ghana instantiate the problem confronted in most parts of Africa regarding policy and regulations in e-waste and its impact on health and the environment (Oteng-Ababio, 2012). In this regard, Kurt et al. (2017) affirmed weak e-waste regulations and lack of attention to safety standards for e-waste workers in Ghana promote unethical practices in e-waste handling. These Practices are

evident at the Agbogbloshie e-waste recycling site in Accra, Ghana (Kurt et al., 2017; Oteng-Ababio 2012; Adanu et al., 2020; Maphosa and Maphosa 2020).

2.2.3 Management of e-waste in Kenya.

Kenya is a party to the Basel Convention and the Bamako Convention. E-waste recycling in Kenya is mostly informal, Chege (2021) reported that only about 10% of e-waste is appropriately managed and others are not properly accounted for. Although there are some formal operators in e-waste management there is a need for capacity building (ITU, 2021). Typical in other LMICs, Kenya also faces challenges in the management of e-waste. Otieno and Omwenga (2015), stated that the low level of awareness, the lack of effective policy and legislative framework and the absence of disposal strategies are issues compounding the management of e-waste in Kenya. National Environmental Management Authority (NEMA) published the guidelines for e-waste management in Kenya in 2010, to help in the management of e-waste across sectors and learning institutions but the guideline was not legally binding. In 2013, NEMA published a draft of e-waste management regulations which contains regulations that allow producers and importers of electrical and electronic waste to take full responsibility for the life cycle of the product (NEMA, 2023). At this stage, Kenya is finalising for approval the 2019 National E-waste Management Strategy and 2020 Extended Producer Responsibility (EPR) Regulations.

2.2.4 Management of e-waste in South Africa.

South Africa ratified the Basel Convention in 2004 however it is not a signatory to the Bamako Convention which is a regional and more articulated agreement addressing the illegal transboundary movement of hazardous waste in Africa (Ghosh et al., 2016; Bimir, 2020). Based on available data, e-waste is managed with other solid waste according to the general environmental protection guidelines as the country still lacks a specific e-waste policy the National Environmental Management Amendment Act 26 of 2014 ((Bimir,2020; Ghosh et al., 2016). Despite the lack of specific e-waste laws, there exist legal frameworks across different government departments tackling the issue of e-waste in South Africa, but informal collectors still operate in tandem with formal collectors (Bimir, 2020). In 2005, the South African Waste Information System (SAWIS) was established to collect data about e-waste generation. The database is a platform where waste generators, collectors, recyclers and exporters register all e-waste-related information (ITU 2021). Conversely, the efficacy of this system is in doubt.

Mmereki et al. (2015), reported that while there is a relatively successful informal sector in South Africa there are still challenges in the handling of the hazardous element of e-waste where some recyclers still neglect fundamental environmental health and safety regulations.

2.2.5 Common disposal practices in LMICs.

Direct dumping of end of useful life electrical electronic equipment with household waste and door-to-door collection by e-waste scavengers from bins and directly from the consumer is frequently practised in LMICs (Balde et al., 2015; Kumar et al., 2017; Forti et al., 2020; Abalansa et al., 2021). Disposal of e-waste along with household waste is reported by many studies as a practice in high-income countries as well (Balde et al., 2015; Balde et al., 2017; Forti et al., 2020). E-waste regulation for Nigeria in the National Environmental (Electrical/Electronic, Sector) Regulations, 2011 stated that there is a prohibition of e-waste disposal alongside domestic and municipal waste. Despite this regulation, e-waste is still being discarded in open dumps, landfills and some find their way to incinerators posing significant challenges to the environment and human health. Unfortunately, the burden of disposal of e-waste generated by high-income countries is bored by LMICs due to the import of end-of-useful life EEE as a secondhand product into the countries (Odeyingbo et al., 2019; ILO, 2019; Mmereki et al., 2016; Abalansa et al., 2021). The challenges of e-waste are recognised by developing countries as such some have developed strategies to manage e-waste in a sustainable way by adopting some regulatory approaches in place in developed countries (ITU, 2021; Bimir, 2020), by integrating the concept of extended producer responsibility (EPR). The concept of EPR is to extend the responsibility to the manufacturer to take- back, recycle and do the final disposal of WEEE (ITU, 2021). The inclusion of extended producer responsibility (EPR) strategy is evident in the National Environmental (Electrical/Electronic, Sector) Regulations, 2011 in Nigeria (ILO, 2019) and Ghana's introduction of an eco-levy on imported used or end-of-useful-life electrical electronic equipment to cover the costs of collection, recovery, recycling and disposal of e-waste stipulated in Act 917 of 2016 (Bimir, 2020; Adanu et al., 2020). In developing a sustainable recycling and disposal system for EEE, two registered licensed recyclers are now established in Nigeria, Hinckley Recycling and E-Terra Technologies (ITU, 2021). Although Ghana has some formal recycling companies, yet e-waste collection and disposal is still dominated by the informal sector (ITU,2021; Adanu et al., 2020). Based on the aforementioned, there is a need for developing countries to consider the

economic gains in the proper management of e-waste, as improper disposal may lead to the loss of precious materials that could have been extracted if e-waste were properly collected, reused and recycled sustainably.

2.2.6 Policy implementation gaps in Nigeria and other LMICs.

Teddy et al. (2019) posit that the implementation of relevant e-waste policies in Low and middle-income countries (LMICs) is ambitious, but the desired results are hardly achieved. Several works of literature have affirmed that e-waste policies and regulations in most low- and middle-income countries are not effective (Kumar et al., 2017; Ohanjinwa et al., 2017; Bimir, 2020; Adanu et al., 2020; ITU,2021). Challenges are bound to exist if e-waste regulations are only a component of an existing waste management or environmental protection legal framework. It is expected that national e-waste policies and regulations should set standard procedures for the collection, transportation and recycling process of generated e-waste. The informal recycling network operates largely outside the guidance of regulations (UNEP, 2007; Abalansa et al., 2021). Inconsistency in policy has been noted as a barrier to implementing e-waste policies in most LMICs (UNEP 2019; Odeyingbo et al., 2019; Bimir, 2020), where activities of interrelated government agencies contradict existing e-waste policy thereby frustrating the efforts of regulatory agencies (Odeyingbo et al., 2017). This scenario is exemplified by the Nigerian case reported in Odeyingbo et al. (2017), where Nigerian customs officials focus on the collection of import duties and only enforce the conformance of declared contents of imported goods. A study by Odeyingbo et al. (2020), confirmed that UEE is not regarded as contraband by the Nigeria Customs Service. Reports from the Person-in-Port (PIP) study by Odeyingbo et al. (2017) have it that cases of improper declarations and labelling of imported contents are common among Used Electrical Electronic Equipment importers. Weak Port regulations were reported in some of the literature as a loophole in e-waste policy and regulations (Odeyingbo et al., 2017; Daum et al., 2017; Odeyingbo et al., 2019; Bimir 2020). Odeyingbo et al. (2017) and Odeyingbo et al. (2019) found that most of the UEEE Imported into Nigeria are loaded in vehicles imported through Roll-on-Roll- off ships (RoRo), making it impossible to know their functionality. LMICs lack sufficient sustainable e-waste recycling facilities, only a few countries have formal recycling facilities but with limited capacity and as such informal recovery and recycling are inevitable (Balde et al., 2017). The non-availability of reliable data on e-waste in developing countries is

a concern and needs to be addressed (Balde et al., 2017; Odeyingbo et al., 2019; Forti et al., 2020). E-waste management and associated complications are comparable in parts of Africa (Balde et al., 2017). The Importation of WEE into developing countries does not immediately impact the environment or the health of the population but the methods of disposal, handling and overall management result in environmental, health and safety hazards. Effective management of e-waste depends on the implementation and enforcement of e-waste-related policies and regulations. The activities of informal e-waste workers lack standard occupational health and safety precautions consequently resulting in various adverse health effects (ILO 2019; Ohajinwa et al., 2017).

A significant amount of e-waste is legally and illegally moved from high-income countries where they are generated to low and middle-income countries with slack or no regulations or policies for e-waste (Lundgren, 2012). This is largely due to the excessive cost of recycling end-of-life electronic electrical equipment and also the fact that high-income countries have stringent e-waste policies (Balde et al., 2017). Informal collection and recycling practices are conducted in rudimentary ways causing environmental, health and safety problems. The activities of informal waste workers lack standard occupational health and safety precautions (ILO 2019; Ohajinwa et al., 2017).

2.3 Extended producer responsibility.

E-waste management is greatly influenced by a policy approach called Extended Producer Responsibility (EPR). This approach assigns the duty of collecting, recycling and disposing of electronic waste to the makers of those products. The goal of EPR policies is to encourage manufacturers to adopt more eco-friendly practices throughout their products' lifecycles (Rautela et al., 2021). This approach represents a significant departure from conventional recycling practices as it expands the responsibility of the producer to encompass the entire life cycle of the product, ranging from production to end-of-life waste management (ILO, 2012; Rautela et al., 2021; Alabi et al., 2021). EPR has evolved into a tailored policy approach that is adopted by many countries in LMICs. In 2009, EPR became recognised as a means of e-waste management in Nigeria (NESREA, 2009). Thapa et al. (2022), reported that there is a growing academic movement advocating for a new approach known as ultimate producer responsibility (UPR). In 2022, a petition called for the European Commission and the

Government of Nigeria to organise repair and recycling for imported second-hand electrical and electronic equipment (EEE) in Nigeria, under a global extended producer responsibility framework (StEP, 2022).

Toward sustainable e-waste management, the Nigerian government has made amendments to the existing regulations to strengthen the country's Extended Producer Responsibility (NESREA 2022). This has placed a regulatory requirement on manufacturers and importers of electronic electrical equipment, recycling facilities and e-waste collection centres to register with the Extended Producer Responsibility of Nigeria (NESREA, 2022). Policymakers need to engage multiple players that are connected and involved to facilitate the effective implementation of policy in e-waste management. It is not only enough for the government to develop regulations and policies for e-waste, but effective implementation and enforcement will result in the overall achievement of the intended goals of such policies and regulations. The policies should complement one another in a unified approach as seen in the SDG Goals where the entire policy is integrated at every point, and no one is left behind (UNEP, 2019).

E-waste management policies can promote the adoption of more environmentally sustainable ones and drive it through the emphasis on behavioural change: this could be linked to the circular economy model where the goal is to produce zero waste and pollution. Products are recycled and reused, products' design lifespans are longer, and end-of-useful-life products are effectively collected and processed in sustainable manners. Low and Middle-Income countries should strive to set up e-waste data systems to track the quantity of e-waste generated locally and imported. This will contribute to the global database and in addition present facts and reliable sustainable information for policymakers.

2.4 Knowledge and awareness of the impact of e-waste hazardous substances on human health.

E-waste is an environmental contaminant and poses various significant threats to human health and safety and children are essentially sensitive to e-waste exposure. Exposures occur through different routes, including ingestion of contaminated food and water, inhaling toxic fumes and particulate matter, and skin contact with chemicals and other corrosive agents (Grant et al., 2013). Exposure to these substances can be influenced by various factors

including the specific type of chemical involved, its form and dose, the duration of exposure, and the route of entry into the body. The adverse health effect depends on the organ or part of the body the hazardous substance is likely to target or penetrate when exposed (Grant et al., 2013; Asampong et al., 2015). Hazardous substances in e-waste can lead to chemical poisoning if directly exposed to or when such pollutants are released into the environment (Alabi et al., 2021; Khuda, 2021). The existence of e-waste contaminants in environmental media and living organisms located near e-waste handling sites serves as an indicator of an increased risk of exposure to harmful substances for the broader population (Awasthi et al., 2018; Orisakwe et al., 2019).

While this persists, a lack of knowledge about the associated health hazards of e-waste to both the environment and humans among the handlers is of concern. Several studies have been conducted to determine the level of knowledge and awareness among e-waste recyclers about the potential hazards associated with their occupation.

A study by Ohajinwa et al. (2017), opined that a good number of e-waste workers interviewed were unable to associate listed chemical substances present in the e-waste. The research findings by Kwatra et al. (2014) indicated that a significant proportion of e-waste workers lacked both knowledge and awareness regarding the potential health effects posed by e-waste. Ohajinwa et al. (2017) focused on e-waste recyclers in Nigeria, it was found that there exists a pronounced deficiency in the awareness level among the recyclers. The result of their study revealed that only 43% of the participants were aware of the requisite Personal Protective Equipment (PPE) necessary to ensure their safety during the recycling process. Similarly, Awasthi et al. (2018) found that 39% of their study participants possessed a limited understanding of the protocols for safe e-waste recycling. This knowledge deficit was not restricted to recycling procedures alone. In a study by Singhal et al. (2021), the research highlighted that only about 36% of the respondents lack awareness of any chemicals released during the recycling process. Furthermore, just 12% of the e-waste recyclers use PPE during their work, and around 26% perceived occupational injuries as trivial concerns, rather than significant health hazards and concluded that knowledge and practices among e-waste recyclers are deficient. In addition, findings from the study by Addae et al. (2023) in Ghana, indicated a negative correlation between recyclers safety knowledge and their safety practices. This means that despite possessing knowledge about safety protocols, many of the recyclers failed to translate this knowledge into safety practices that will enhance their

occupational health and safety. The emerging themes from these studies underscored the overarching theme that e-waste recyclers often lack the requisite knowledge and awareness essential for safeguarding themselves against occupational hazards and potential health effects. There is an urgent need to enhance the knowledge and awareness levels among e-waste recyclers. Crude recycling activities engaged by these scavengers at collection sites and in a designated workplace present health, safety, and environmental problems that need careful assessment and consideration, especially in LMICs such as Nigeria. Addressing this gap through research and taking critical steps towards ensuring the health and safety of this workforce is highly needed.

2.5 Safety and health outcome of occupational exposure to e-waste toxicants and hazards related to informal e-waste recycling.

Electronic waste recycling is complex because of its components, and recycling with crude methods such as sorting, manual dismantling, shredding, and open burning, is widely practised in LMICs. These practices release hazardous chemicals in e-waste and workers are directly exposed. Toxicants that are being exposed to are heavy metals and compounds that have adverse effects on health (Ohajinwa et al., 2019; Burns et al., 2016). Pieces of evidence of health effects due to long-term exposure were reported in many studies (Ohajinwa et al., 2019; Igharo et al., 2021). Exposures are through dermal contact, inhalation and ingestion from hand to mouth (Grant et al., 2013; Burns et al. 2016; Alabi et al., 2020; Li and Achal, 2020). Concentrations of contaminants have been recorded to be present in the matrices of e-waste workers in studies conducted in many studies. Wittsiepe et al. (2017), reported significantly higher concentrations of blood lead (Pb), cadmium (Cd), chromium (Cr) and nickel (Ni) in the urine of e-waste workers when compared to the control group in their study. An earlier report by Popoola et al. (2019), showed a high level of blood lead in the occupationally exposed e-waste workers who have worked between 1 and 5 years as e-waste scavengers. Alabi et al. (2020), assessed the blood level metal among teenage scavengers and results indicated a significantly higher concentration of Pb, Ni, Cd, and Cr in the blood samples when compared to the control group. Tahir et al. (2020), showed that urinary metal concentrations in zinc (Zn), iron (Fe), copper (Cu), Ni, Cr, arsenic (As), and Cadmium (Cd) of the studied informal e-waste workers were high compared to the control group but the level of iron had

no significant difference between the exposed and the control group (this indicate that the control group has another means of accumulating iron). Findings in a recent study by Isaah et al. (2021), also indicated that blood and Urine lead levels were significantly higher in e-waste workers (exposed) and the control group (non- e-waste exposed) at Agbogbloshie. Adverse health outcomes are associated with short-term and long-term exposure to toxic substances associated with e-waste handling and are dependent on several factors that include the type of chemical, dose, mode, and timing of exposure. The adverse health effects of some heavy metals and toxicants found in e-waste are discussed in the next section.

2.5.1 Health impact of elemental and organic contaminants in electronic waste.

Lead intake can cause neurotoxic effects, cognitive and behavioural problems, especially in children and hypertension and kidney damage in adults (Grant et al. 2013). Short-term exposure can at the start cause headaches, muscle pain and malaise. Long-term exposure can lead to permanent damage to the nervous system especially in children (Yang et al.,2017; Alabi et al. 2020). A common route of exposure is through inhalation of dust, fumes, ingestion of contaminated food or water, or skin contact during the recycling process (Alabi et al. 2020). Accordingly, Issah et al. (2021) found a significantly high level of lead in e-waste workers in Ghana in their study. Moreso during e-waste recycling, lead can leach from discarded devices and contaminate soil and water sources. Adam et al. (2021) in their review of the hazards and exposure during e-waste processing, indicated that there are serious risks to the environment and humans through recycling activities.

Mercury is one of the heavy metals with neurotoxic substances and potential health effects are kidney and lung damage, and disruptions to the immune system (Burns et al., 2016). Short-term exposure can initially cause lung and eye irritation, chest pain, diarrhoea, nausea, skin rashes and high blood pressure. Long-term exposure can damage the central nervous system and Kidney (Burns et al., 2016; Igharo et al., 2016; Wittsieppe et al., 2017).

Inhaling vapours and fumes during manual dismantling and burning are common practices in informal e-waste recycling (Annamalai, 2015). Mercury can vaporise at room temperature and be inhaled and capable of contaminating water and food sources as this has been established by studies carried out in e-waste recycling sites (Decharat, 2018; Amponsah, 2022).

Cadmium is released into the environment during informal electronic waste recycling which often involves rudimentary techniques (Igharo et al., 2016; Awasthi et al., 2016). Thus, leading to the exposure of the individuals involved in such processes. The health effects associated with exposure to cadmium are of great concern. Short-term exposure effects include a severe form of pneumonia, chest pain, cough, headache, dryness of the throat as well and muscle aches (Fu et al., 2008). Inadvertent ingestion of cadmium could lead to nausea, vomiting, diarrhoea and abdominal cramps (Wittsiepe et al., 2017). Long-term exposure to Cadmium has been found to have a chronic health effect on humans(Alabi et al., 2021). Lung conditions such as chronic obstructive pulmonary disease and kidney damage are the primary accumulation points in the body (Chen et al., 2011). Long-term exposure during pregnancy can potentially lead to developmental concerns such as low birth weight, deformities in newborns and reproductive problems in males (Chen et al., 2011; Awasthi et al., 2016).

Chromium particulates are released into the air during acid bathing and burning of e-waste to extract valuable materials (Zheng et al., 2012). Several studies have established the health effects associated with exposure to the metal even in children (Zeng et al. 2016). This crude processing of e-waste by informal recyclers exposes them to inhalation, ingestion, and direct dermal contact with chromium compounds (Grant et al., 2013; Heacock et al., 2016). This results in adverse health effects based on the duration of exposure. Short-term exposure causes shortness of breath, coughing and respiratory discomfort including damage to the kidney and liver (Herat, 2008; Heacock et al., 2016). Dermal contact could lead to skin rashes, skin irritation and Skin Ulcers (Grant et al., 2013). Chronic exposure results in respiratory issues such as asthma and lung cancer and negatively affect the male reproductive system (Grant et al., 2013; Orisakwe et al., 2019).

Beryllium is a metal commonly found in computers and some other telecommunication equipment (Annamalai, 2015; Singh et al., 2019). There are potential hazards inherent when exposed to the dust and fumes emitted during informal e-waste recycling when proper Personal Protective equipment is not used or used correctly. Health effects associated with short-term exposure, when inhaled, are coughing, chest pain and shortness of breath. Skin contact could result in skin ulcers and rashes (Grant et al., 2013; Kumar and Singh 2019). Potential health effects associated with long-term exposure include Chronic Beryllium Disease (CBD) known as lung disorder which can occur even shortly after intense exposure

incidents. Symptoms include respiratory, fatigue, and heart complications (Grant et al., 2013). A high risk of lung cancer is envisaged with exposure to beryllium dust (Annamalai, 2015).

Antimony is a chemical element present in various electronic devices, and informal recycling increases health hazards for e-waste workers, studies have found in humans from electronic e-waste sites in China, Ghana and Alaba International Market area in Lagos Nigeria (Huang et al., 2015; Tokumaru et al., 2017; Isimekhai et al., 2017; Wu et al., 2019;). When the element dust disperses into the air, it poses health risks. Workers can be exposed through inhalation, ingestion, and dermal contact. Effects of short-term exposure include sore throat coughing, eye irritations, skin rashes and redness are common effects (Li and Achal, 2020). Associated long-term effects are cardiovascular issues leading to constant chest pain and prolonged inhalation could have adverse effects leading to pneumoconiosis and the potential to cause lung cancer (Li and Achal, 2020).

Zinc is an essential trace element and helps in the functioning of the chemical processes that occur within living organisms (Roohani et al., 2013; Popoola et al. 2019). These functions include wound healing, protein synthesis, neurological functions, DNA synthesis as well as antioxidant roles in the body (Roohani et al., 2013). While they are needed to perform these listed vital functions in the human system, excessive exposure can pose adverse health risks. This element is used in the manufacturing of electronic components, thus informal recyclers are at risk of excessive exposure that could lead to acute and chronic effects (Popoola et al., 2019). There is evidence of accumulation of Zinc in e-waste recycling sites in Lagos Nigeria according to various studies (Adaramodu et al., 2012; Isimekhai et al., 2017; Popoola et al., 2019; Orisakwe et al., 2019). The main route of exposure is inhalation (Grant et al., 2013), particularly when burning and melting electronic parts without protective measures and releasing residues into the surroundings (Orisakwe et al., 2019; Singh et al., 2018). Other sources include inadvertently ingestions and skin contact with contaminated surfaces (Grant et al., 2013). Short-term exposure can result in vomiting, loss of appetite, nausea, diarrhoea, headaches, shortness of breath and increased respiratory rate as well as skin and eye irritation (Zeng et al., 2016). Long-term effects of exposure to zinc during informal e-waste recycling can lead to neurological effects, existing respiratory disease complications, copper deficiency in the body system, and weak immunity (Awasthi et al., 2016; Orisakwe et al., 2019).

2.5.2 Toxic organic contaminants.

Polybrominated diphenyl ethers (PBDEs) are a group of flame-retardant compounds broadly used in various electronic devices to inhibit ignition and reduce the risk of fire (Nnorom and Osibanjo, 2008; Rautela 2021; Oloruntoba et al., 2022). Their persistent nature raises considerable concern for bioaccumulation in the environment and the human body (Ohajinwa et al., 2019; Oloruntoba et al., 2022). They are resistant to degradation and persist in the environment and in organisms for a long time. They can leach into the soil and water systems and then be picked up by small organisms and plants forming the process of bioaccumulation (Ohajinwa et al., 2019). The major source of PBDEs in Nigeria has been linked to e-waste recycling activities (Oloruntoba et al., 2022). Constant exposure to high levels of PBDEs has been associated with many health problems in humans, including neurodevelopmental and behavioural issues in children, thyroid hormone disruptions, and even potential carcinogenic effects (Grant et al., 2013; Zheng et al., 2017) as long-term impacts. The fact that humans are at the top of many food chains, the bioaccumulation of PBDEs and other toxic substances from e-waste poses significant health risks (Frazzoli et al., 2010; Ohajinwa et al., 2019), especially for those working directly with e-waste or living near the e-waste recycling sites.

Polybrominated biphenyls (PBBs) are a group of synthetic, brominated flame retardants that have been used in various industrial applications, including in certain electronic components, to reduce the risk of fire (Ankit et al., 2021). It is Persistent in the environment bioaccumulates in organisms and is associated with adverse health effects including endocrine disruption, neurodevelopmental toxicity, and potential carcinogenicity as long-term effects (Okeme and Arrandale, 2019). Within the informal e-waste recycling sector, the inadvertent release of PBBs, primarily through crude dismantling processes and open burning, poses severe health implications (Orisakwe et al., 2019).

Triphenyl phosphate (TPhP) is a chemical compound regularly utilised as a flame retardant in many electronic devices (Balasch et al., 2022). Its benefit is to reduce flammability in the electronic components but there are problems with its potential health impacts. These problems are imminent when released during crude e-waste recycling processes at informal recycling sites such as open burning (Bai et al., 2018; Orisakwe et al., 2019; Rautela et al., 2021). Dietary exposure has been evidenced in some studies in China, where TPhP was found

in homemade eggs in an e-waste recycling area (Zheng et al., 2016). Chronic effects of exposure to Triphenyl phosphate (TPhP) have been associated with potential endocrine disruption, reproductive health concerns, and neurological effects (Bai et al., 2018).

Polyvinylchloride (PVC) is a commonly used plastic material found in several electronic devices (Ankit et al., 2021). While Polyvinylchloride itself does not bioaccumulate in organisms, certain additives used in the preparation of PVC such as phthalates have the potential to bioaccumulate in organisms (Deng et al., 2021). Phthalates have been discovered in many environmental samples within e-waste recycling sites and have been evidenced that they can accumulate in food chains (Deng et al., 2021). The processing of PVC in informal e-waste recycling settings is of considerable concern due to the resultant environmental and health hazards. Open burning of PVC can result in the emission of highly toxic compounds and dioxins that are of concern (Rautela et al., 2021). These chlorinated compounds, when inhaled or ingested, can cause a range of acute health effects and long-term complications, including potential carcinogenic outcomes (Ankit et al., 2021).

2.5.3 Injuries and noise.

In addition to exposure to harmful chemicals, injuries and illnesses are common among e-waste workers including self-reported noise exposure, (Asampong et al., 2015; Burns et al., 2019). Ohajinwa et al. (2019), in their study, concluded that noise exposure is capable of producing short-term increases in average heart rate which are likely to predict potential damage to the cardiovascular system. E-waste recyclers are seen as at risk of injuries and exposure to hazardous substances associated with work performed during the collection and extraction of useable materials where personal safety is not prioritised in the entire process (Burns et al., 2019). Workers carry out their duties with crude techniques and near-zero safety practices (Igharo et al., 2016), self-reported slips, falls, bruises, cuts, burns body pains have been reported (Popoola et al., 2019; Sapna, 2019; Zolnikov et al., 2021; Asampong et al., 2015). Burns et al. (2019), documented 400 injuries among e-waste workers in 6 months period at Agbogbloshie, more injuries were from dismantling because of lacerations from sharp objects due to a lack of safety precautions.

2.6 Informal e-waste recycling and its impact on the environment.

Informal e-waste recycling causes environmental contamination, e-waste consists of hazardous substances like heavy metals and persistent organic pollutants (POPs) as such informal processing releases these contaminants into the environment. Toxicants in e-waste can be deposited in soil, air, dust and water resulting in various environmental processes including bioaccumulation, and food contamination among others and thus leading to widespread exposure (Song and Li, 2014; Isimekhai et al., 2017; Li and Achal, 2020). This widespread exposure distorts the normal functional activities of the ecosystem and results in continuing degradation (Robinson, 2009; Song and Li, 2015). Jiang et al. (2019), conducted a study on the impact of heavy metals on the soil at the Alaba international market area in Nigeria. The researchers found that the heavy metal contents in the soil samples generally exceeded the soil screening standards set by the United States Environmental Protection Agency (USEPA) and European regulations. The estimated metal concentration of some e-waste recycling sites was higher than that of the non-recycling sites as observed in many studies (Li and Achal, 2020; Alabi et al., 2021; Awasthi et al., 2018). The studies by Alabi et al. (2021), Ohajinwa et al. (2019), and Yang et al. (2017) confirmed that contamination occurs in the air when particles and toxins are released into the atmosphere during dismantling, shredding and burning of e-waste to extract valuable materials. Air contamination during crude recycling activities negatively impacts the environment consequently human health is adversely affected. Studies have shown that the concentration of Polybrominated diphenyl ethers (PBDEs) and heavy metals in the indoor dust and air samples collected from e-waste recycling shops is significantly higher. This is in comparison to samples taken from non-e-waste recycling sites (Alabi and Bakare, 2015; Olukunle et al., 2015; Orisakwe et al., 201; Cai et al., 2020; Mowla et al., 2021). Similarly, harmful particles released due to informal e-waste recycling can be deposited into the soil and leaked through to the surface and underground water. Plants are contaminated in this process and as a result, the end-users are affected (Awasthi et al.,2018; Li and Achal, 2020; Orisakwe et al.,2019). As mentioned earlier once the soil is contaminated heavy metals deposited are leached through the soil to reach the underground water, reports of vegetation and soil contamination by chemicals and heavy metals from informal recycling e-waste sites have been reported in Agbogbloshie, Ghana (Alabi et al., 2021). Awasthi et al. (2018), submitted that in China most recycling sites are contaminated with heavy metals and other toxins and that both the surface water and

underground water are affected, therefore, the lakes, streams and rivers are contaminated making it difficult to access potable drinking water. Lin et al. (2022), in their study, found an increase in PBDE levels in soils and residue and in homegrown eggs in locations near e-waste recycling sites in Quingyan, China. In the food items analysed in this area, fish appears to cause greater exposure to organic compounds like Polychlorinated biphenyls (PCB), Polychlorinated dibenzodioxin (PCDD) and Polybrominated diphenyl ethers (PBDE) in the people who reside nearby the e-waste sites. Environmental pollution can extend beyond recycling sites and cause soil and water contamination which are mostly irreversible. Similarly, Eze et al. (2022), in their findings show that e-waste soil extract from areas about 2 kilometres away from the recycling sites at Alaba International Market in Lagos, Nigeria, Godome-Kouhounou, Cotonou, in Benin and Agbogbloshie Accra in Ghana contain complex toxicants which may present adverse effect on human and the environment.

2.7 Exposure risks among non-e-waste workers and other vulnerable populations.

Exposure risks are a significant concern not only among informal e-waste recyclers but also among other vulnerable populations. While the focus of research has predominantly been on the health and safety issues confronted by informal e-waste workers, it is important to acknowledge that other individuals may also face exposure risks. The surging e-waste volume and exposure to its toxic components are not only occupational but relate to the general population and even the unborn. Various studies including, Grant et al. (2013), Ohajinwa et al. (2019), Orisakwe et al. (2019), Popoola et al. (2019), Alabi et al. (2020), Adam et al. (2021), Rautela et al. (2021) have indicated that not only e-waste workers are at risk from exposure from harmful toxicants from e-waste handling but also the environment in general. Inhabitants within the recycling sites and vulnerable populations such as children, pregnant women, and breastfeeding women may be affected. Orisakwe et al. (2019), reported in their study that headache, chest pain, cough, stomach pain, miscarriages, abnormal thyroid, limited reproductive functions, drop in gonadal hormones and cancer are common complaints among inhabitants of an e-waste community. Vulnerable populations such as pregnant women and children are also affected. Furthermore, they explained that e-waste recycling sites in sub-Saharan Africa comprise sizeable support services and businesses such as cafeterias, street trading, food vendors and shelters thus exposure to e-waste pollutants is

spread beyond e-waste workers. It is noteworthy that non-e-waste workers, residents, and children around the e-waste recycling sites are potentially at risk of adverse health effects from the hazards of informal e-waste recycling activities (Ohajinwa et al.,2019). In a similar trend in China, individuals living within and near e-waste recycling areas have a high probability of exposure to toxicants in e-waste, as matter-of-fact various studies conducted showed an elevated level of metal in blood among these people (Li et al., 2020; Li and Achal, 2020). The vulnerability of children is imminent when exposed to hazardous substances from e-waste recycling activities. According to a WHO report, 5.9 million children died before their fifth birthday in 2015, but 26% of those deaths could have been prevented if environmental risks were tackled (WHO, 2017). Environmental exposure begins in the womb and may result in negative effects all through life, consequences could be long-term which are adverse health outcomes of identifiable defects during childhood and linger to adulthood (Chen et al., 2011; Grant et al., 2013; Cai et al., 2019; Adam et al., 2019). The Global increase in e-waste generation has been perceived as one of the emerging risks and children are particularly vulnerable (WHO, 2017). A body of work exists that has linked low birth weight, congenital abnormalities and neurodevelopment issues to fetal exposure to hazardous chemicals such as those emitted during informal e-waste recycling (WHO, UNU 2013; Grant et al., 2013; Singh et al., 2021). Evidence from earlier studies suggests that combined exposure such as early life exposure and later increased environmental exposure to hazardous substances could result in later in-life health challenges (Grant et al., 2013; WHO, 2017; Cai et al., 2019). Studies carried out in many parts of the world established the relationship between health and hazardous materials contained in e-waste, on this note it is factual to say we need a healthy and supportive environment for good health, this means that the environment we live in is a major determinant of our health and wellbeing.

2.8 Concept of quality of working life.

The term quality of work life evolved in research in the early 1970s and intensified during the international conference on the quality of work life held in 1972 (Martel and Dupuois, 2006). One of the key conclusions of the conference was to recognise and harmonise the works of the researchers and organisations in developing a concrete framework in the research of

quality of work life (Martel and Dupuois, 2006). Quality of work life is not just about contentment with a job and productivity, it is an index of general well-being.

Lawler and Nadler, (1983) refer to the quality of working life as "an individual's perception and attitudes towards his work and the overall work environment". Lawler and Mirvis (1984), safe working environment, fair pay, and opportunity for career growth among others as factors considered in the quality of work life.

Quality of work life refers to workers' perception of the factors in their work environment and how they influence their physical and psychological well-being (Moda et al., 2021).

The delineations of QoWL have been modified over time and this is largely subjective to the theoretical position of the scholars. Sirgy et al. (2001), in their paper, identified QoWL as "employee satisfaction with a variety of needs through resources, activities, and outcomes stemming from participation in the workplace". Furthermore, they opined that need satisfaction arising from workplace practises impacts job satisfaction and other satisfaction in life domains and this is likened to the need-satisfaction model developed by Maslow. Sirgy et al. (2001) identified seven domains namely " (a) health and safety needs (protection from ill health and injury at work and outside of work, and enhancement of good health), (b) economic and family needs (pay, job security, and other family needs), (c) social needs (collegiality at work and leisure time off work), (d) esteem needs (recognition and appreciation of work within the organization and outside the organization), (e) actualization needs (realization of one's potential within the organization and as a professional), (f) knowledge needs (learning to enhance job and professional skills), and (g) aesthetic needs (creativity at work as well as personal creativity and general aesthetics)". Based on their research, these seven dimensions collapse into two major categories: lower-order and higher-order needs. Lower-order QWL consists of health/safety needs and economic/family needs; higher-order QWL includes social, esteem, self-actualization, knowledge, and esthetic needs (Marta et al., 2013). These domains are comparable to Maslow's needs theory (Sirgy et al., 2001; Ranawat, 2015). Almakhi et al. (2012), in their study of health workers, found that an unconducive working environment, inadequate facilities, and unsuitable working hours are factors that negatively influence their quality of work life. Maslow's theory of needs (1981) is made up of five levels of human needs as shown in Figure 2.4.

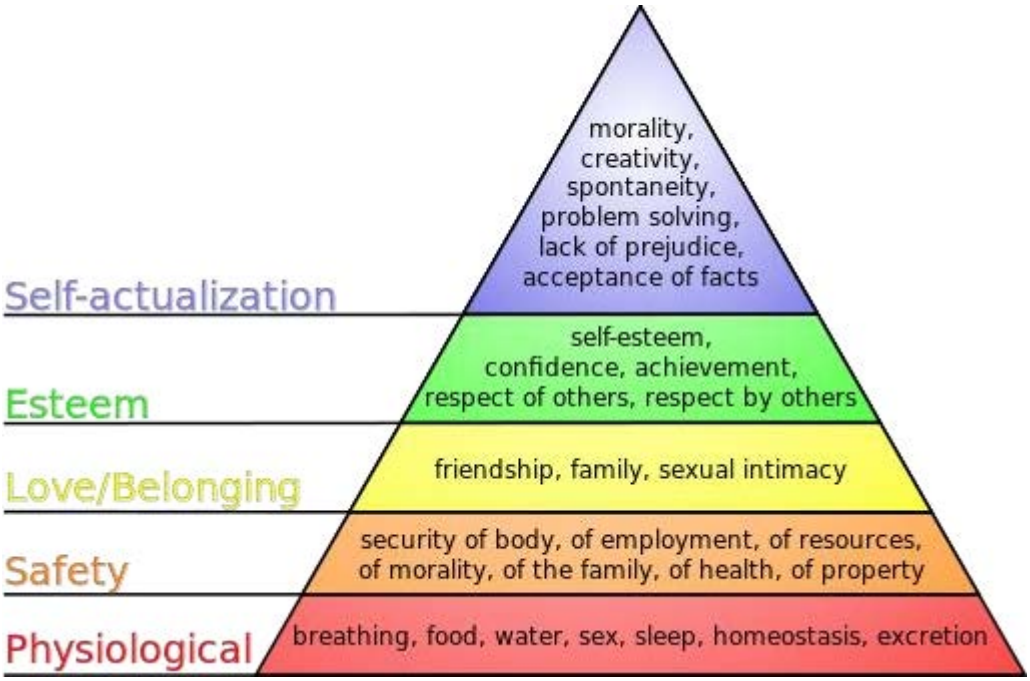

Figure 2.4: Maslow theory of need (Source: Harrigan and Michael, 2015: Online)

2.8.1 Overview of workplace perspective of Maslow's theory

The hierarchy of human needs in Maslow's theory falls into three categories.

Basic needs- physiological and safety needs; Psychological needs- love and belonging, and esteem needs; Self-fulfilment- self-actualisation (Sirgy et al., 2001). The needs at the base of the hierarchy are paramount and realised before working towards the next one. Maslow highlighted that these needs are unstable as humans can move in reverse in the hierarchy when any of the needs are put at risk or become unsatisfied (Sirgy et al., 2001).

Physiological needs- These are the basic human needs necessary to survive and are identified as the foremost of all the needs in the hierarchy (Sirgy et al.,2001). They present in any form depending on the individual's narrative and their pressing needs for them especially as it affects survival (Maslow, 1981). Many individuals may be overpowered by the desire to satisfy their physiological needs, making other needs in the hierarchy secondary and unimportant. The availability of basic facilities such as a sheltered working environment, access to clean toilet facilities, steady and sustainable income, clean water, break time, eating space and

training are provisions that should be made available to workers (Chan and Wyatt, 2007; Almalki et al., 2012). However, these needs are to a certain extent difficult to meet in informal work settings, unlike formal and more organised settings.

Safety needs- A safe working environment is a priority for all workers. It is salient that physical safety and protection from all work hazards by providing adequate personal protective equipment (PPE), a secure environment, provision of ergonomic office furniture, job security and other necessary support at work (ILO, 2014). This includes implementing safety protocols, providing training and resources to address potential hazards, and fostering an environment (ILO, 2014). Studies show that workers who perceived their workplace as safe and secure reported an optimal quality of work life (Lee et al.,2015)

When the workplace lacks adequate safety, the workers are burdened with having to deal with personal safety and this results in dangerous working conditions as seen among informal e-waste recyclers. Health and safety concerns should not be the burden of an individual worker, there should be statutory procedures at the workplace to protect the workers.

Love and belonging- The workplace perspective of this level in Maslow's theory is linked to a sense of belonging and inclusion at work. This includes positive interpersonal relationships, communication, team building, trust and other social needs and affiliations like family and friends (Osabiya, 2015). According to Maslow, a person makes every effort to identify with a group and attain a place there.

Esteem- This hierarchy consists of those factors that can raise a worker's self-esteem such as recognition at work, the feeling of achievement, positive feedback and respect from others. Satisfaction of the need in this hierarchy results in feelings of self-worth, confidence, capability, and the competence of being valuable. Hindering the satisfaction of these needs yields feelings of inferiority, helplessness, weakness and lack of self-worth to the individual (Maslow, 1981; Sirgy et al., 2001). Informal workers may face societal stigma and a lack of recognition for their contributions according to Zolnikov et al. (2021). Informal workers may experience limited opportunities for career growth and skills development, which can impact their self-esteem and satisfaction with their work.

Self-actualisation- The self-actualisation needs develop after all the needs from the base of the hierarchy have been encountered and gratified. This is a state of confidence about abilities, a state of complete satisfaction and that all other needs have been met and are not threatened. The chance for a worker to develop their full potential, engage in meaningful

work, and align their values and passions with their job will promote overall well-being, job satisfaction, and fulfilment (Efraty and Sirgy, 1990; Narehan et al., 2014).

This study has considered variables such as basic pay, availability of toilet facilities and potable water at work, occupational stress, safety at work, general well-being, the balance between work and family life, training, skills and competencies, job flexibility and autonomy and overall sense of satisfaction which are all comparable to Maslow theory of needs. The theory provides the framework for viewing people's needs. The intersection between Maslow's hierarchy of needs and QWL underscores the significance of creating a positive work environment that promotes adequate job satisfaction and work-life balance, as these factors are vital to meeting higher-order needs and achieving personal development and overall satisfaction. In general, work in this area is in its infancy and to the best of the researchers' knowledge, this is the first work to consider the quality of work life among the e-waste recyclers segment of informal workers in Nigeria.

2.8.2 Quality of working life among informal e-waste recyclers in Nigeria.

E-waste recycling activities in Nigeria are dominated by the informal sector, the International Labour Organisation has it on record that about 61.2 per cent (2 billion) of the world's workforce is in the informal sector. Further analysis showed that a higher proportion of informal workers are in Africa and Asia and are mostly youth and women (ILO, 2018). The share of informal workers in sub-Sahara Africa where Nigeria lies is 76.8 per cent (excluding agriculture) and 56.3 per cent in North Africa (ILO, 2018). Workers in the informal sector lack the influence that those in the formal sector have. Typically, the formal work organisation is required to provide social security coverage, annual paid leave, sick leave and health insurance coverage in some instances, adequate training from time to time to keep up with the evolving process of work and the provision of other well-being support. In contrast, the informal sector is not under strict regulations or mandated by any benefit scheme for the workers. The workplace settings are mostly on small or medium scales characterised by limited use of technology and resort to crude methods in carrying out day-to-day recycling procedures. Workers are mostly with little or no skills, earn a low income, and saddled with unfavourable working conditions. Informal work conditions put people at a higher risk of vulnerability including occupational health and safety risks. ILO (2019) stated that the global

working poverty rate declined since 2000, but the rate has slowed down in the past 5 years. Moreover, the rate is particularly high in sub-Sahara Africa with 38% employed below the international poverty mark. Individuals employed in the informal e-waste recycling sector are those from poor backgrounds who have limited or no formal training (Lundgren, 2012). The lack of access to training and skills development opportunities often limits the ability to move into more secure and higher-paying jobs. This can lead to feelings of job insecurity and low job satisfaction (ILO, 2019).

A report by ILO in 2012 stated that in Ghana informal e-waste recyclers are struck with a lack of employment security, hazardous working conditions, poor earnings and health. Similarly, in India of the e-waste generated 95% of it are recycled in the informal sector characterised by the same working techniques and conditions seen in Nigeria and Ghana (Annamalai, 2015; Dutta and Goel, 2021). They engage in various survival activities, their employment is unstable and are burdened with marginal income that is as well not fixed (Xaba, 2002). Generally, there is a prevailing lack of effective work organisation and structure within the informal sector. Socioeconomic and working conditions such as insufficient income, the high number of working days per week, and perceived violence at work are associated with increased stress (Kêdoté et al., 2022). Job stress puts individuals at risk of non-communicable diseases such as hypertension and also vulnerability to communicable ones such as skin infections, tetanus, vector-borne diseases and other diseases that may occur due to a weakened immune system (Case study 2015; Asampong et al., 2015; Zolnikov et al., 2021).

The measure of the quality of working life will provide key information required for assessing contentment among the target group for use in planning interventions, monitoring workforce experience and assessing the effect of workplace change (Edwards et al., 2008; Moda et al., 2021). Thus, knowledge gathered in this regard is key to uncovering the underlying factors that will advance the improvement of informal workers' quality of work life.

2.9 Workplace Safety Practices and Behaviour among Informal Recyclers

While e-waste contains precious metals and valuable materials, the process of extraction requires well-calculated sustainable procedures. According to Balde et al. (2017), an estimated 20% of e-waste is recovered and recycled in a sustainable approach, while the outstanding 80% are transported to Low- and middle-income countries (LMICs) despite the

existence of agreements such as the Basel Convention, Nairobi Declaration, Bamako Convention among others. However, in LMICs like Nigeria e-waste recycling is dominated by the informal sector with no infrastructure and as such recycling processes are carried out in unsafe manners (Perkins et al., 2014; Nnorom and Odeyingbo, 2019; Okeme and Arrandale, 2019). Ghana is also confronted with a similar dilemma of informal e-waste recycling as Nigeria (Daum et al., 2019; Adusei et al., 2020).

Control methods and safety behaviour adopted by scavengers in the management of hazardous substance exposure in informal e-waste recycling are limited. This is crippled by limited resources, lack of knowledge and awareness and poor regulations. According to International Labour Organisation (2014), individuals involved in the informal handling of e-waste are mostly lacking the adequate awareness and training necessary to process recycling in a sustainable manner that is deemed suitable for occupational safety and health, and decent work criteria. The occupational safety and health programme aims to promote a safe and healthy working environment and protect the public who may be affected by the working environment (ILO, 2014; Ohajinwa et al., 2017). Likewise, in the UN Sustainable Development Goal 8 'Decent work and economic growth,' themes in the associated targets include decent work with equal pay, education and training and safe working environments (UNSDGs Report). There are still set back in achieving the SDGs in LMICs, in the data presented by Sachs et al. (2022), Sustainable Development Report 2022, the world made no progress in the SDGs performance index from 2019 to 2021 and furthermore performance in the SDG 8 in many LMICs remain below the pre-pandemic levels.

Informal recycling activities are mostly carried out in rudimentary techniques by dismantling with the use of basic tools such as hammers, screwdrivers and bare hands, open burning and heating, acid-bathing to recover precious metals and indiscriminate disposal of materials in open fields, waterways, and canals (Adanu et al., 2020; Annamalai,2015). Workers are usually focused on the output of the job and disregard the health and safety risks associated with the job. Risks involved include exposure to toxic substances and pollutants that are of public health concern such as Polychlorinated Biphenyl (PCBs), Polybrominated diphenyl ethers (PBDEs) and other heavy metals such as Lead (Pb), Cadmium (Cd), Mercury (Hg), Hexavalent Chromium (Cr6+), Barium (Ba), Arsenic (As), Selenium (Se), Beryllium (Be), Polyvinyl Chloride (PVC), during electronic waste recycling activities (Song et al., 2015; Arya and Kumar, 2020). The individual workers are exposed (Popoola et al., 2019), and the environment is also

negatively impacted including putting other people at risk of associated adverse impacts many studies have confirmed this claim. Alabi and Bakare (2015), in their study, confirmed that people who are living and working in the environment at Alaba in Lagos Nigeria, where informal e-waste activities occur are also at risk as the e-waste recyclers themselves. Orisakwe et al. (2019) and Li and Achal (2020) assert that living around e-waste handling facilities potentially predisposes broader populations to increased risks of exposure to hazardous substances associated with e-waste.

2.9.1 Occupational Risk Behaviours of Informal e-waste Workers

Deficient safety conditions, practices or violations can cause harm such as slipping and falling, and musculoskeletal disorders (Burns et al., 2019; ILO, 2014). Pathways of exposure are inhalation, dermal contact, and injection from hand to mouth. The exposure dose and the absorbed dose depend on the frequency of contacts, timing, and the level of toxicity of the substances, once they enter the body system can result in disease (Grant et al.,2013; Awasthi et al., 2016). The non-usage of the appropriate PPE, the absence of equipment, and disregard for relevant procedures are prevalent among them. There is a tendency that the e-waste workers in these sites are only bothered with physical injuries and burns and are not aware of potential exposure that could lead to occupational diseases such as respiratory illness, cardiovascular diseases, and cancer among others (Grant et al., 2013; Daum et al., 2017). This is attributed to a lack of knowledge and awareness of the potential hazards in their work activities.

The global incidents of work-related diseases, injuries and death are worrying. The joint reports by the International Labour Organisation (ILO) and World Health Organisation (WHO) estimated that 1.9 million people died because of work-related diseases and 81% of the deaths were caused by non-communicable diseases in 2016 (WHO and ILO, 2021). The Nigeria Country Profile on Occupational Safety and Health (2016), a joint publication between the ILO and the Federal Ministry of Labour and Employment, acknowledges the lack of adequate data due to underreporting of occupational accidents and diseases; large and growing informal sector; and significant young and inexperienced workforce as threats and weaknesses to the occupational safety and health system in Nigeria.

Occupational health and safety measures are lacking in informal sectors, and risky recycling processes that undermine safety procedures are engaged in by informal e-waste recyclers and may result in injuries and illnesses. According to Acquah et al. (2019), a high level of stress and musculoskeletal disorders were recorded among e-waste recyclers observed in their study in Ghana. A study of e-waste recyclers in Nigeria by Igharo et al. (2016), indicates a high degree of occupational exposure to toxic e-waste chemicals among e-waste workers may predispose them to cancer development due to a lack of knowledge and near-zero safety practices. Similarly, Alabi et al. (2020), mentioned that occupational safety is not prioritised by informal e-waste handlers, and this predisposes them to risks involved in their work activities. The lack of emphasis on safety measures in their work environment potentially contributes to hazardous conditions and increases the likelihood of accidents and health issues among these workers.

Occupational risks are increased due to the exposure to hazards while recycling e-waste informally in unsafe manners using crude manual techniques. In the studies reviewed, generally, the work safety culture of informal e-waste workers was poor. Burns et al. (2016), during their research at Agbogbloshie, observed that e-waste workers operated outdoors, mostly with no overhead cover and without any form of personal protection and the same observations were also reported by Yu et al. (2016) and Wittsieppe et al. (2017).

In informal e-waste recycling settings, occupational safety is not prioritised, and there is low awareness of the intensity of the risk associated with informal recycling activities (Alabi et al., 2020). Self-reported chest pain, injuries and cuts have been reported by e-waste workers according to Asampong et al. (2015) but their health-seeking practices such as self-prescribed medications, and the application of lubricants and detergents to wounds put them more at risk. Yang et al. (2017), noted that a lack of washing facilities could easily facilitate the ingestion of toxic substances and possibly transport home the harmful substances to their families. A variety of physical injuries are prevalent among informal e-waste recyclers and are associated with a lack of adequate protection during recycling activities (Burns et al., 2019; Asampong et al., 2015; Ohajinwa et al., 2019). E-waste recyclers lack awareness and knowledge of better practices in carrying out their jobs, consequently putting their lives at risk.

The lack of formalities and strict regulations to procedures could make it difficult for informal e-waste recyclers to behave safely while carrying out their jobs. Internal code of practices by

local trade unions may not be sufficient to achieve a favourable safety climate but can be promoted with increasing awareness through various means that can positively influence them. Some studies have been conducted in the construction industry regarding safety behaviour and the extent to which group norms have influenced their safety behaviours (Choi et al., 2017; Andersen et al., 2017; Choi and Lee, 2022). In these studies, it was found that safety behaviours were significantly influenced by their group's shared values and beliefs. To achieve specific SDGs 3 and 8 targets that include the reduction of the number of deaths and illnesses caused by pollution and contamination by hazardous substances; and the promotion of a safe and secure working environment, it is pertinent to raise the level of awareness, and knowledge and improve safety practices among scavengers to prompt safety and health-promoting behaviour in the workplace. It is generally difficult to draw a clear distinction between collectors and recyclers as many recyclers are equally involved in the collection of e-waste. This is mainly due to the significant overlap in roles and this fluidity in roles blurs the traditional boundaries between collectors and recyclers (Perkins et al., 2014).

2.9.2 Safety climate

Safety climate is considered a workplace characteristic that impacts safety outcomes in a work environment. It refers to the shared perceptions, attitudes, and beliefs regarding safety within an organisation or work environment (Zohar, 2011; Schneider et al., 2013). Neal and Griffin, (2002), described safety climate as the shared perception of procedures, practices and behaviour of workers in a workplace. Safety climate indicates the overall safety culture and the extent to which safety is prioritised, valued, and practised in a workplace (Griffin and Curcuruto, 2016; Hale, 2000). It plays a crucial role in shaping collective safety-related behaviours, attitudes, and outcomes in the workplace (Deng et al., 2020). Many authors in their studies have identified that safety climate is influenced by a range of factors which include leadership, communication, policies and procedures, safety training and competencies, resources, well-being, and the physical work environment (Reicher and Schneider, 1990; Griffin and Neal 2000; Zohar, 2003; Christian et al., 2009). However, Huang et al. (2006), in their work identified that there are differences in safety climate perception and individual perception. Individual safety perception refers to an individual's subjective level of knowledge, and awareness of safety hazards, risks, and their respective safety

behaviours within the work environment (Neal and Griffin, 2002). This reflects an individual's level of experience and understanding of health and safety-related factors such as hazards in work procedures, safety practices, and the effectiveness of safety measures that are in place. Individual commitments to the factors that help promote safety in the work environment provide a positive outcome that shapes the safety climate (Christian et al., 2009; Neal and Griffin, 2006). A formal workplace typically has defined safety guidelines and expectations regarding safety practices with measurable standards (Neal and Griffin, 2002). This measure creates a safe working environment that reduces potential hazards and risks of accidents and injuries. On the other hand, there are fewer defined guidelines, compliances and regulations on safety practices in informal work settings such as the informal e-waste recycling sites in Nigeria (Ohajinwa et al., 2017; ILO, 2017). This absence of clear safety practices and procedures can result in increased risks and vulnerabilities for the workers engaged in informal recycling activities (ILO, 2017).

2.9.2.1 Safety climate in the informal work environment

Much research on safety climate has focused on formal work environments, there is a growing interest in understanding the same concept in informal work environments. The informal workplaces include small-scale industries, informal e-waste recycling settings, and other unregulated sectors (ILO, 2017). The presence of an unstructured and unregulated work environment, such as those found in informal e-waste recycling sites, presents a significant challenge when assessing the safety climate.

There are unique challenges and risks associated with these unregulated environments. An unfavourable safety climate potentially exposes individual workers to a higher risk of accidents, injuries, and unsafe work practices including health and well-being issues (Christian et al., 2009; Tucker and Turner, 2015; Griffin and Curcuruto, 2016). An analysis conducted by Clarke (2013), reported an association between higher safety behaviour and reduced workplace injuries. The safety climate in informal e-waste recycling settings is influenced by factors attributable to the characteristics of these work environments. Factors that are most likely to influence how workers perceive and prioritised safety have been outlined as follows:

Socioeconomic factors: Informal e-waste recycling is often driven by economic necessity and entry for workers who may be facing limited employment options (Asampong et al., 2015).

The lack of alternative opportunities may result in workers accepting hazardous conditions and engaging in risky behaviour due to financial pressures and livelihoods (Orisakwe et al., 2019; Zolnikov et al., 2021). Insufficient financial resources to access appropriate equipment as pointed out by Burns et al. (2019), represents a factor that can potentially undermine the safety climate within an informal work environment.

Safety policies, procedures, and regulatory oversight: Informal e-waste recycling settings typically lack formal safety policies and guidelines, enhanced by the limited enforcement of regulations (ILO, 2019). The lack of standardised safety procedures and guidelines can lead to increased risks for workers involved in handling e-waste. The operation of the sector is mostly outside the regulatory framework and enforcement of safety standards which contributes to the adoption of unsafe work practices (Khuda, 2021). Rautela et al. (2017), also indicated in their study that a lack of awareness that there are rules and regulations that should be followed is a problem among informal e-waste recycling workers.

Exposure to hazardous substances: E-waste often contains hazardous substances such as heavy metals as earlier identified in this study. Without proper safety measures and personal protective equipment (PPE), workers may be exposed to these substances, leading to long-term health effects (Grant et al., 2013). Burns et al. (2016), stated that risk factors for cardiovascular diseases are increased due to exposure to heavy metals that are likely to be emitted during informal e-waste activities. The health conditions of workers have been identified as part of indicators in considering the safety climate in a workplace (Nahrgang et al., 2011; Griffin and Curcuruto, 2016).

Unsafe work conditions: Informal e-waste recycling settings lack proper infrastructure, absence of adequate ventilation systems, protective barriers and workplace factors that create unsafe work conditions (Asampong et al., 2015). In the absence of appropriate ventilation, workers are constrained to operate in spaces where harmful pollutants persist, posing severe health risks. Alongside this, the lack of protective barriers further amplifies these hazards, leaving workers exposed to harmful materials and substances. Workers are likely to be exposed to physical hazards like sharp objects, broken glass, trips and falls increasing the risk of injuries (Burns et al., 2016). The risk of physical harm is further worsened by the cluttered and chaotic nature of informal recycling settings. In these environments, the

risk of trips and falls increases significantly, posing an added threat to workers physical well-being.

Limited training and awareness: Workers in informal e-waste recycling settings mostly have limited occupational training and awareness regarding the potential hazards associated with e-waste (Fischer et al., 2020). This lack of knowledge increases the likelihood of accidents, injuries, and exposure to toxic substances (Yu et al., 2016; Ricci et al., 2016; Burns et al., 2019). Several studies have established a connection between low educational attainment, reduced awareness of hazards with adherence to safety practices among informal e-waste recyclers (Yu et al., 2016; Yang et al., 2017; Burns et al., 2019; Ohajinwa et al., 2019).

Poor waste management at recycling sites: According to Ferronato and Torretta (2019), the increasing rate of solid waste production is alarming, and its management is becoming a concern, especially in LMICs. In the absence of adequate waste management practices, e-waste could be stored or discarded in open areas. Thus, increasing the risk of exposure to hazardous substances and the contamination of soil and water sources (Awasthi et al., 2018; Orisakwe et al., 2019). The inappropriate disposal of dust particles, chemicals used for extractions and residue from burnt materials are hazardous to the workplace and the environment has been reported in some studies including Adam et al. (2021).

2.9.3 Training and safety behaviour

According to the International Labour Organisation (2014), enhancing occupational health and safety through the development of skills among informal workers is required. This includes providing them with relevant knowledge, training, and capacity-building opportunities to effectively identify and mitigate workplace hazards.

Safety training programs play a vital role in promoting workplace safety and reducing occupational hazards. This is also relevant for workers in the informal sector, such as informal e-waste scavengers, who often face precarious working conditions and limited access to formal training opportunities (Burns et al., 2019; Zolnikov et al., 2021). Nigeria is a country with a sizeable informal e-waste recycling sector (Ogungbuyi et al., 2012). There are pieces of evidence of unique occupational hazards and risks among the recyclers, thus making the need for safety training crucial for their well-being.

Likewise, the influence of safety training among informal workers in the Nigerian construction industry has been identified by studies (Adeogun and Okafor, 2013; Okoye et al., 2016). The results indicated that individuals who undertook safety training demonstrated increased levels of safety consciousness, adherence to safety protocols, and the implementation of safe work methods. The evidence of the importance of training in providing informal workers with the essential competencies and expertise to recognise and mitigate workplace health and safety hazards has been supported in many studies in the construction industries (Idubor and Osiamoje, 2013; Idowu and Iyabo, 2017; Idoga, 2018)

The efficacy of safety training programs among informal waste collectors in Nigeria has been discussed in various studies (ILO, 2014; Ohajinwa et al., 2018). It was established that training is an enhancement in safety knowledge, proficiency in identifying hazards, and the utilisation of personal protective equipment as a result of the training interventions. The findings in more studies also underscored the importance of customised training initiatives that specifically target the unique hazards and difficulties encountered by informal e-waste workers in Nigeria, Ghana and some LMICs. (Burns et al., 2019; Ohajinwa et al., 2018).

Ricci et al., (2016) summarised in their study that it is important to consider the impact of safety training effectiveness on workers' knowledge, attitudes, and behaviours. They further highlighted that it is important to take into account factors such as training modality, trainers characteristics, setting, session duration, assessment instruments, and their subsequent outcomes.

In considering and addressing these factors, policymakers and stakeholders can enhance the provision of tailored safety training in promoting a safer work environment for informal e-waste recyclers.

2.9.3.1 Group identity and safety behaviour

In their recent study, Tear and Reader (2022) explored the potential role of social identity as a mediator between safety culture and safety behaviour. While the concept of "safety" does not fundamentally fall within established social categories of group identity, previous research on opinion-based groups has demonstrated that individuals can come together and form groups based on shared opinions, fostering a sense of collective purpose (Tear and Reader, 2022). The findings of Tear and Reader's study propose that embracing a social

identity perspective in safety culture research and intervention initiatives could offer valuable insights and avenues for the development of safety-oriented identities and practices. Similarly, Andersen et al. (2018) explored group identification among construction workers and its connections with social identity, safety climate, and work-related accidents. The findings of their research indicate that workers predominantly identify themselves with their workgroup, followed by less identification with the construction site. However, the study revealed a positive relationship between social identity and safety climate at both the workgroup and construction site levels, suggesting that social identity plays a significant role in influencing safety climate within these contexts (Andersen et al., 2018).

Choi and Lee (2022) highlight the significance of Social Identity Theory (SIT), which asserts that an individual's strong identification with a group plays a vital role in promoting positive behaviours within the group. Consequently, individuals who strongly identify with the group are more likely to exert additional effort to enhance the group's performance. Sabbir et al. (2023), recently examined the relationship between sustainable consumer behaviour, particularly the practice of trading old electronic devices for new or refurbished ones as a sustainable way to recycle electronic waste, and Social Identity Theory (SIT) in Bangladesh. The findings include establishing a new theoretical link that deepens the understanding of how collective cultures, uphold sustainable consumer behaviour. This highlights the significant influence of Social Identity Theory in promoting positive behaviours and attitudes towards sustainable practices, like e-waste reverse exchange, within such cultural settings (Sabbir et al., 2023). By fostering a collective sense of belonging and shared identity within the context of safety, individuals may be more inclined to engage in safety-conscious behaviours, ultimately influencing overall safety behaviour positively (Andersen et al., 2018; Cho and Lee, 2022). This suggests that incorporating a social identity perspective may hold promise in advancing safety-related interventions and strategies, enhancing our understanding of safety culture, and ultimately fostering a safer work environment.

Considering the empirical findings and theoretical underpinnings, it is posited that Social Identity Theory (SIT) holds considerable potential as a fundamental framework for fostering positive safety behaviour among specific groups, notably those operating in the informal sector, such as scavengers working in informal recycling sites. There is a noticeable lack of research exploring the effect of group identity on safety behaviour and safety climate among

informal e-waste recyclers. Especially when compared with findings in the construction industry where collective efforts and group identity have helped to shape safe behaviour at work. This study is designed to bridge that knowledge gap and contribute meaningful data and perspectives that will enhance existing knowledge in this aspect of research.

2.10 Sustainable e-waste management

There exist challenges in solid waste management and now more complicated with the increasing use of electrical and electronic equipment (EEE) and the inflow of electronic waste into LMICs (Liu et al., 2009). The decrease in the life cycle of EEE and the precipitous growth in technology are contributing factors that are increasing e-waste generation (Osibanjo and Nnorom, 2008). The actual occupational health, safety and environmental impact of e-waste arise during improper processing of e-waste such as those practices by informal recycling (Osibanjo and Nnorom 2007). The informal sector performs a substantial part in e-waste management in several LMICs (Zolnikov et al., 2012; Yang et al., 2017; Rautela et al., 2021). Informal recycling activities involve primitive methods of dismantling and processing e-waste without the use of appropriate safety measures (Igharo et al. 2016). Forti et al. (2020) reported that in 2019, the Global E-waste Statistics Partnership found that 17.4% of e-waste that was collected and properly recycled prevented the release of up to 15 million tonnes of carbon dioxide equivalent into the environment. E-waste is an environmental health threat and where inadequate disposal and management of e-waste are allowed it tends to impact human health and well-being. Fort et al. (2020) noted that ideally e-waste should be formally collected and managed at a specialised treatment plant to help recover valuable materials while hazardous substances are controlled to prevent their escape.

The United Nations Sustainable Development Goals are interrelated such that action in a particular target can influence outcomes in other goals (United Nations, 2015; Balde et al., 2017). This study particularly supports SDG 3 (Good health and well-being), SDG 8 (Decent work and economic growth) and SDG 11 (Sustainable cities and communities). Likewise, the African Agenda 2063, themed 'Africa we Want' was formulated in 2013 as a 50-year framework to achieve sustainable development across the continent (African Union, 2013). While there are differences in their scopes and specific targets, there are significant relationships between Africa 2063 and the SDGs (African Union report, 2022; Royo et al.,

2022). Africa 2063 and the SDGs are both essential frameworks for sustainable development, with Africa 2063 tailored to the specific circumstances of the African continent, and the SDGs providing a global framework for all (African Union report, 2020; Royo et al., 2022).

Effective management of e-waste can lead to a decrease in adverse health risks and mortality rates among children and adults and reduce environmental pollution (Balde et al., 2017). It will encourage the establishment of safe and protected working conditions and environments for all individuals in the workforce, with specific attention to vulnerable and informal workers who are engaged in precarious employment (Balde et al., 2017; ILO, 2019; Forti et al., 2020). At present, e-waste processing in LMICs is predominantly carried out in the informal sector, where most occupational activities associated with e-waste disposal and recycling lack adequate safety measures and are not covered by formal regulations (Shittu et al., 2021). It is therefore crucial for countries to formalise the environmentally responsible management of e-waste and exploit the business prospects it presents.

A greater part of e-waste is predicted to stem from urban areas, underscoring the significance of implementing suitable e-waste management practices in cities (Balde et al., 2017; Forti et al., 2020). There is a need to conserve air quality and improve the entire waste management practices which include e-waste management processes (WHO, 2021). This demands the heightening of the collection and recycling rates while minimising the disposal of e-waste in landfills. There are safe control methods and practices recommended for an ideal e-waste scenario like the formal sector because they are regulated. The process of collection, recycling, and disposal of electronic waste in an environmentally sustainable manner will help reduce the adverse effects of e-waste on human health and the environment.

2.10.1 Sustainable e-waste management approaches

The health, safety and environmental impact of improperly managed e-waste cannot be overstated and as such there is a need to take the right actions. Aside from the health safety and environmental factors, there are social and economic impacts of not managing e-waste properly. Sustainable Development Goals Report (2020) stated that only 17.4% of e-waste was collected and recycled and therefore, valuable materials such as silver, gold, copper, palladium and platinum were lost.

2.10.2 Circular economy model

The circular economy model for e-waste management aims to reduce e-waste generation and increase resource recovery to foster sustainable consumption and production. (Forti et al., 2017; Lieder and Rashid, 2016). The Circular Economy model components include- the efficiency in e-waste collection and reducing the generation of e-waste by promoting sustainable consumption patterns (Forti et al., 2020; Rautela et al., 2021). Reusing by extending the life of electronic products by repairing, refurbishing, or repurposing them for continuous use (Pan et al., 2022). Recycling processes by separation, and processing of e-waste to recover valuable materials in an environmentally sustainable manner. It includes the extraction of metals, plastics, and other resources from e-waste that can be used in the making of new products (Shittu et al., 2021; Pan et al., 2022). The sustainability required to promote a healthy environment and economic development can be achieved through the circular economy approach (Lieder and Rashid, 2016). Many studies have highlighted the importance of adopting a circular economy model. Rautela et al. (2021) and Awasthi et al. (2019), in their studies, noted adopting the circular economy model in the e-waste recycling processes will enable material recovery and return to the manufacturer for use in another production. According to Singh and Ogunseitan (2022), increasing the average useful life of a device by 50% is equivalent to reducing the manufacturing requirement of approximately one-third of the total device. On the other hand, these authors also argued that prolonging the useful lifespan of electronic products could potentially limit access to cutting-edge technology. Furthermore, reducing e-waste generation may not directly result in a decrease in informal workers exposure to hazardous components of e-waste (Singh and Ogunseitan, 2022). There is a need to adopt a model that encompasses the management of e-waste throughout its entire life cycle.

Considering the viewpoints expressed by the authors above, it is asserted that the circular economy model holds the potential to offer sustainable alternatives for the management of e-waste. It is pertinent to have strategies and approaches to drive the circular economy. On this note, the European Commission Waste Framework Directive 2008/98/EC now called WFD 2008 provides an approach to waste management. In this framework, waste streams are ordered into fragments in the form of a hierarchy that will influence their management

approach. The concept of this framework focuses on the upper level of the hierarchy which is prevention, reuse and recycling as can be seen in Figure 2.5. The other considerations include energy recovery and the least is disposal (Gharfalkhar et al., 2015; Zhang et al., 2022). Within the circular model, the waste hierarchy aligns with the preservation of resources and efficiency (Gharfalkar et al., 2015; Cole et al., 2019; Zhang et al., 2022). The following is an overview of the waste management hierarchy in the context of e-waste management:

Prevention- This includes the use of policies and practices that suppress the use of hazardous materials in electronic and electrical equipment (WFD 2008). Encouraging manufacturers to design products with longer lifespans and reduce the need for frequent replacements (Forti et al., 2017).

Reuse- Promoting the development of second-hand markets for used electrical and electronic goods, supporting the reselling and reuse of devices that are still in working condition (WFD 2008). This aspect can include the creation of programs that aid the refurbishment and reuse of functional electronic devices (Pan et al., 2022).

Recycling- Investing in recycling infrastructure for e-waste, including facilities capable of safely extracting valuable materials from discarded electronics without creating adverse health or environmental impacts (WFD 2008; WHO, 2021). There is a need to create support for informal e-waste recyclers ensuring they meet environmental and health standards.

Recovery- This involves the recovery of other critical materials from e-waste, promoting resource efficiency as specified in CE (WFD 2008; Rautela et al., 2021). Exploring energy recovery options for e-waste that cannot be recycled could involve controlled incineration with energy capture (Cole et al., 2019). The development of technologies and methods for recovering valuable metals and materials from electronic waste through sustainable processes is considered in this level of the hierarchy.

Disposal- According to the European Commission Waste Framework Directive 2008/98/EC (WFD 2008), this is the last level of the hierarchy and the least considered. Adequate care should be taken to ensure safe and regulated disposal practices for e-waste that cannot be managed through other hierarchy levels. It is critical to minimise the environmental impact of landfills by properly managing electronic waste disposal sites. The disposal of e-waste materials in dumpsites is still widely practised in some LMICs (WHO, 2021). The crude

recycling methods adopted in these countries such as Nigeria, allowed the disposal of unrecovered resources in landfills (Babayemi et al., 2016). It is pertinent to prioritise responsible disposal methods that minimise harm to the environment and human health.

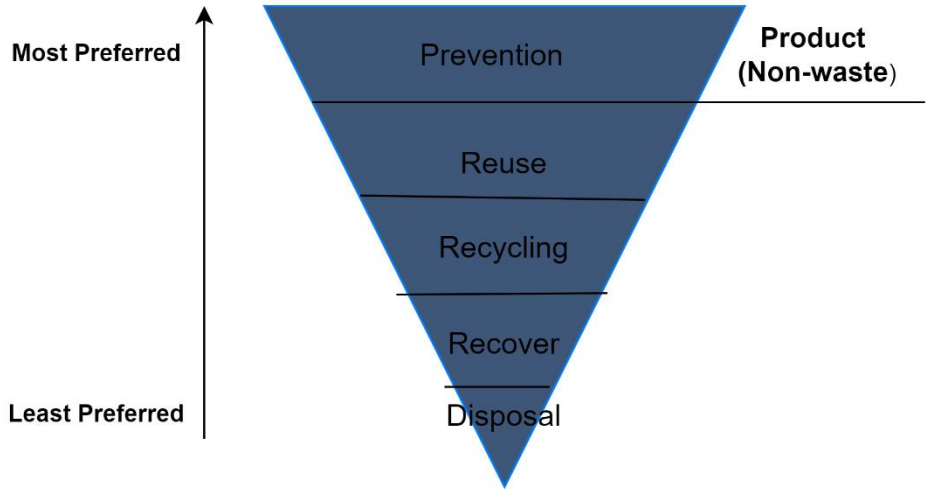

Figure 2.5: Waste Management Hierarchy (Source: WFD 2008)

The adoption of this framework in the management of e-waste will enable sustainability and minimise the health impact of e-waste. The waste hierarchy framework has its gaps and disparities as identified by Cole et al. (2017). However, integrating the waste hierarchy with circular economy principles in e-waste management in LMICs such as Nigeria provides a sustainable approach. This is also predicted to address environmental and economic aspects throughout the lifecycle of electronic products (Cole et al., 2019; Ofori and Mensah, 2021). Behavioural interventions and aligning waste management practices with the waste hierarchy concept can enhance the effectiveness of the circular economy model in the management of e-waste.

Summary of the gaps in the literature

In exploring the existing literature for this study, it becomes evident that considerable research has been conducted on e-waste management in LMICs. Further examination of the literature reveals several notable gaps and areas necessitating further exploration of the aspects of informal e-waste recycling in Nigeria. Based on the empirical findings and

theoretical perspectives of the studies reviewed, there are limited studies that have exploited the theoretical and conceptual dimensions adopted by this study. This highlights a notable gap in the existing literature in this area of research. The Health Belief Model (HBM) is based on psychological and behavioural theory, focusing on individual perceptions of health risks and the belief in the values that are derived from particular health behaviours. In the aspect of workplace health and safety, the HBM can be influential in identifying workers perceived susceptibility to workplace hazards, the severity of potential health consequences, the benefits of adopting safety measures, and barriers to the adoption of positive health and safety behaviour in the workplace. It is posited that Social Identity Theory (SIT) holds considerable potential as a fundamental framework for fostering positive safety behaviour among specific groups. This also applies to those operating in the informal sector, such as recyclers in the recycling sites. There is a noticeable lack of research exploring the effect of group identity on safety behaviour and safety climate among informal e-waste recyclers as seen in the research within the construction industry. The conceptual framework in this study combined HBM and SIT to create a more robust framework that can aid in a better understanding of the recyclers workplace health and safety practices. In addition, it provides insights into creating intervention strategies to promote both the adoption and sustained practice of health and safety behaviours within the informal e-waste recyclers group.

Reviewing existing institutional e-waste safety and health policies in Nigeria revealed that there exist weak e-waste regulations in the country. The need for suitable e-waste disposal and management facilities made it viable for informal recycling dominance in Nigeria. Given that the recycling sector is dominated by informal settings, this creates difficulties in implementing government policies and regulations effectively. There is a need to point out the areas that are lacking to enable policymakers to make effective policies. Several studies have been conducted to ascertain the potential hazards related to e-waste management. Adverse health consequences are connected with short-term and long-term exposure to toxic substances accompanying e-waste handling. Informal e-waste recycling and its impact on the environment cannot be underestimated. In addition, the exposure risks among non-e-waste workers and other vulnerable populations were evident in various studies. There is still a level of lack of knowledge and awareness of the magnitude of the potential adverse impact of the hazardous substance of e-waste on human health and the environment among informal

recyclers. The study assessed the level of knowledge and awareness among informal recyclers to understand the threshold of their workplace health behaviour and safety practices.

Extensive research has been conducted within the formal sector in aspects such as workplace safety practices and behaviour, occupational risk behaviours, safety climate, training impact on safety behaviour, and the influence of group identity on safety behaviour. However, there is a noticeable lack of sufficient studies that investigated these themes in the informal sectors, especially within the informal e-waste recycling workplace. This underscores a significant gap in the literature that calls for focused attention and exploration. As indicated by other researchers, the measure of the quality of working life provides key data needed for assessing contentment among the target group for use in planning interventions, monitoring workforce experience and assessing the effect of workplace change. Maslow's Hierarchy of Needs theory was explored in the context of the quality of work life among informal workers to provide an understanding of the dynamics of motivation, job satisfaction and well-being. However, a search for literature in this area of research shows that it has not been exploited among the e-waste recyclers segment of informal workers in Nigeria. Thus, this study specifically assessed informal e-waste recyclers to gather knowledge in this area to uncover the underlying factors that will enhance the improvement of their quality of work life.

Sustainable waste management approaches have been supported by the United Nations Sustainable Development Goals in tackling some global challenges such as health and environmental issues. While the SDGS goals are connected, this study identified goals 3, 8 and 11 as those with targets that include the effective management of e-waste to protect human health and the environment, and the promotion of a secure and safe work environment. Implementation of a circular economy model that incorporates the proper waste management practices such as the waste hierarchy concept has been advocated as an effective strategy to address the challenges posed by e-waste. However, the successful implementation of these approaches will require robust policies informed by empirical data to drive their adoption and ensure their effectiveness in achieving sustainable outcomes. Therefore, this study contributes valuable data that will play a vital role in providing insight and guiding pertinent future actions, and policies.

3.0 CHAPTER THREE: METHODOLOGY

3.1 Introduction

The section discusses the methodology adopted for this study such as the philosophical views, methods, design, data collection and analysis. The research aims to assess the level of health and safety awareness and evaluate the quality of work life among informal e-waste recyclers to enhance their occupational health, safety practices, and overall work experience.

The objectives of the research study are listed below:

i. To measure scavengers' knowledge and awareness of the impact of e-waste hazardous substances on human health
ii. To measure the relationship between educational attainment and the level of safety and health practices adopted among the e-waste handlers.
iii. To assess existing control methods and safety behaviour adopted towards the management of hazardous substance exposure among the scavengers.
iv. To assess the quality of working life (job contentment, work condition, general wellbeing) among e-waste scavengers.
v. To assist in the development of measures to promote safety and health policy, and workplace safety awareness in the management of e-waste among informal workers.

The choice of methodology for this study was based on adopting the most appropriate way to explore the research topic. The researcher considered various factors in making this choice, such as the philosophical assumptions underlying the research, the research designs that provide the procedural frameworks and the specific methods used for data collection, analysis, and interpretation. The nature of the research problem, research questions, the researcher's personal experiences, and the intended audiences for the study also influenced the selection of a research approach which supports the perspectives of Creswell and Creswell, (2018) and Saunders et al. (2019). This chapter will present the structure of the research methodology in chronological order following the broad concept identified by Creswell and Creswell (2018). The broad sections are research approaches, research design and research methods as illustrated in Figure 3.1 below. These sections have different components that make up this chapter.

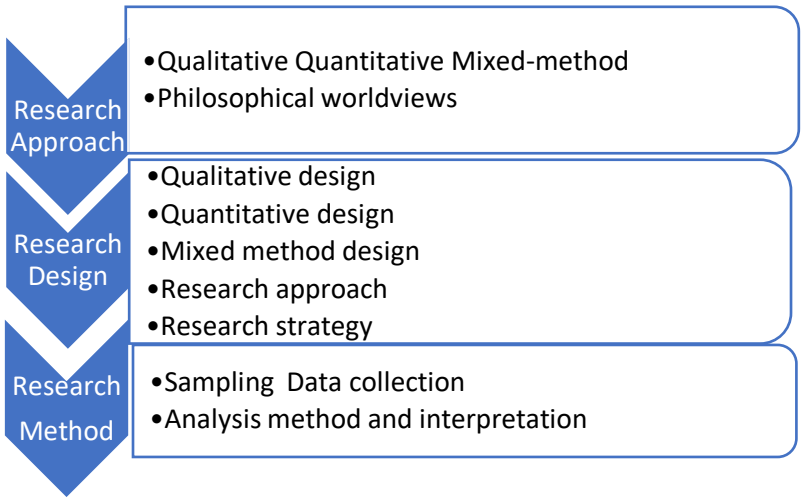

Figure 3.1: Overview of the study structure

3.2 Research approaches

The choice of a research approach depends on its alignment with the research problems, aims and objectives. According to Creswell and Guetterman (2018), it is important for researchers to avoid identifying qualitative and quantitative approaches as rigidly defined, separate categories, or opposing viewpoints. Instead, these approaches should be seen as representing different points along a continuum. Mixed methods lie in the middle of this continuum, combining both qualitative and quantitative elements (Creswell and Creswell, 2023). Every approach is embedded in distinct philosophical worldviews and paradigms (Creswell and Creswell, 2018), providing researchers with a structured blueprint to investigate a research problem.

The merits of quantitative research stand out, particularly for certain types of study. It focuses on gathering, measuring and analyses of numerical data to find patterns, relationships, associations and trends among the variables being studied (Creswell and Creswell, 2018; Saunders et al., 2019). This approach is grounded in the principles of measurement, statistical analysis, and objective observations. Quantitative research often uses large sample sizes, standardised instruments, and structured data collection methods (Nardi, 2018). It is a method immersed in the use of statistical evidence to answer research questions, test

hypotheses, and generalise findings to a larger population (Bryman, 2016). Fields like psychology, sociology, health sciences, and economics often lean towards this approach. Given the study's objectives, type of questions formulated, hypotheses, and significant sample size, a quantitative research approach was adopted. This decision was further shaped by other underlying assumptions, perspectives, and beliefs, which will be elaborated upon in the subsequent section on research philosophy.

3.3 Research philosophy

Methodological choice in research is guided by philosophical assumptions and is based on the researcher's position. Research philosophy is beliefs and assumptions that give a distinctive approach to research (Creswell and Creswell 2018). They are an imperative part of the research methodological framework as they steer the direction of the research. Creswell and Creswell (2023), indicate that integrating philosophical beliefs in a study is crucial as they provide valuable guidance for interpreting the researcher's standpoint. Furthermore, the authors stated that an ongoing debate persists regarding the specific worldviews that researchers bring to their inquiries. This philosophical standpoint discloses the researcher's notions about the research, and they are also referred to as paradigms (Guba, 2011; Zukauskas et al. 2018). There are some prominent research philosophy inclinations, Creswell and Creswell, (2018) have identified four generally considered worldviews namely post-positivism, constructivism, transformative and pragmatism. Creamer, (2018), opined that paradigm is not about being spontaneous but applying a suitable philosophical basis to support the adoption of a specific methodology. The following are key highlights of the research philosophy:

3.3.1 Post-positivism

Post-positivism is a research philosophy that builds upon positivism (Creswell and Creswell 2018). The assumption in post-positivism is that in seeking knowledge researcher should strive to follow a systematic theory to produce the evidence, knowledge is acquired by drawing from theories (Creswell and Tashakkori, 2007). Therefore, this philosophy is of the opinion that occurrences are proven only in empirical and scientific methods but acknowledges that our understanding of reality is intervened by our perception and interpretation. It suggests that our knowledge is fallible and subject to revision based on new

evidence and interpretations (Philips and Burbules, 2000). This explains why researchers do not tend to prove hypotheses but test them with evidence and then support or reject them (Creswell and Creswell, 2018). Therefore, post-positivism fosters critical thinking through the consideration of alternative explanations, and the recognition of the researcher's role in shaping knowledge (Philips and Burbules, 2000, Creswell and Creswell, 2018).

3.3.2 Constructivism

Constructivism holds the belief that occurrence can be inferred in a subjective means and is seen as a suitable assumption for qualitative research (Creswell, 2014). Additionally, this philosophical approach argues that human behaviour and occurrences are not completely implied by an objective or theoretical approach (Creswell, 2014; Creswell and Creswell, 2018). This explicitly implied that the researcher takes part in scrutinising the occurrence and the view they uphold. Constructivist researchers focus on exploring the underlying meanings, perspectives, and contexts in interpreting people's experiences. They use qualitative methods such as interviews, open-ended questions, observations, and document analysis to uncover the diverse interpretations and social processes (Creswell and Creswell, 2018). They held the view that human behaviour or answers to research problems are embedded within the deeper understanding of perspective, context, opinions and interpretations (Ryan, 2018).

3.3.3 Transformative

A transformative philosophical view is a belief that provides understanding and explanations to research that promotes social change and emancipation (Tashakkorie and Teddlie, 2003). The proponents believe that the postpositivist necessitated theories and other rigid ways of evaluation as the means of research (Creswell and Creswell, 2023). They also held the view that the constructivist viewpoint did not well fit into solving an action-oriented research problem (Creswell and Creswell, 2018). The transformative philosophical view is embedded in the critical theory system in analysis (Tashakkorie and Teddlie, 2003). It is entrenched in an inquiry that sought experiences of diverse groups that have been marginalised or oppressed or have been caught up in issues because of power dynamics (Mertens, 2010). Mostly, the research that holds this philosophical worldview according to various authors (Tashakkorie and Teddlie, 2003; Creswell, 2014; Creswell and Creswell, 2018) embraces a mixed methods approach by combining qualitative and quantitative methods including collaboration with participants to effect social change.

3.3.4 Pragmatism

Pragmatism philosophy is driven by practicality, where knowledge should be based on context and the perspectives of the researcher (Cresswell and Cresswell, 2018). Pragmatists held the opinion that researchers should employ various options and be adaptable as much as they could when seeking knowledge (Tashakkorie and Teddlie, 2010). The researcher has the liberty to make a choice of the methods that best meet the intended purpose of the research. This gives the researcher the liberty to adopt research approaches, methods, and procedures that best provide the answer and understanding of the problem under study (Creswell, et al. 2018). Based on the proponents of this research philosophy, it is permissible to say that a pragmatic worldview allows the researcher the choice to adopt a combination of quantitative and qualitative and can employ multiple methods in their research approach.

Working out paradigms due to diverse opinions and navigating the realm of debatable worldviews pose significant challenges for researchers (Yafeng, 2020). Despite the variation in how paradigms are described and reviewed there are still shared perspectives that still signal a connection to their descriptions (Cameron, 2011). Researchers commonly combine multiple perspectives to align with their research questions, aims and objectives. It is important to note that selecting a research philosophy worldview has consequential effects on research design, methods for data collection and analysis, and the interpretation of the findings.

3.3.5 Components of research philosophy

Specific typical research philosophies have been considered earlier; it is important to discuss the various components that shape the dimension of research philosophies. They help to illustrate the philosophy of research in their different directions by shaping the approach to knowledge, understanding of reality, and research methods in a study (Žukauskas et al., 2018). According to Denzin and Lincoln (1998), and Žukauskas et al. (2018) “the components of research philosophy include ontological, epistemological and methodological assumptions”.

Ontology describes the researcher's assumptions underlying the nature of reality and how it can be comprehended (Kivunja and Kuyini, 2017). It is about the views of the problem and its reality including the possible solutions. It is concerned with what is considered real and the assumptions that there could be only one reality which is known as the concept of singularity

where reality can be studied objectively (Denzin, 1998). Another assumption is that there could be multiple realities or truths of the knowledge and that there are multiple realities and interpretations (Denzin and Lincoln, 1998). Thus, the ontological approach can be objective or subjective depending on the research aims, objectives and the researcher's philosophical stands.

Epistemology is the assumption of how we seek the truth and collect knowledge and is pivotal to any assertion that contributes to knowledge (Hofer, 2001). Epistemology is an underlying component of research philosophy, about the beliefs and understanding of knowledge and how it is created. It explores the nature, sources and scope of knowledge, and the methods engaged to acquire knowledge (Hofer, 2001). It is a component of the philosophical assumptions that shape how research is conducted (Godwin et al., 2021). Hofer (2001) asserted that epistemology beliefs are numerous, firstly, Knowledge can be measured with the use of reliable tools and designs then, Knowledge is interpretive so needs to be explained, also knowledge is validated when examined by using the best tools, designs and interpretations.

Axiology component refers to the function of value in the research process. It acknowledges the consequences of values and the potential biases that may set in during the research process (Kivunja and Kuyini, 2017; Saunder et al., 2019). Axiology accentuates the importance of ethical considerations and adherence to the process put in place for the research integrity and the overall impact (Saunders et al., 2019; Teddlie and Tashakkori, 2012). This includes the process of participants recruitment, minimising the risk of harm and adhering to the guidelines of anonymity and confidentiality in the research.

Accordingly, Žukauskas et al. (2018), described methodology as a research component that is related to the researcher’s belief about how research should be performed, these are considerations about the methods and techniques that are applied in a research study. The researcher should seek the best approach to find knowledge considering that the methodological choice is informed by the nature of the research questions and objectives. This includes methods of data collection, analysis and interpretation. Methodologies could be qualitative, quantitative or mixed methods according to Ivankova and Wingo, (2018).

The researcher's preference for specific ontological, epistemological, axiological, and methodological notions greatly influenced the research philosophy and the approach

employed in the study. These considerations ensured the research was grounded in a coherent and consistent theoretical framework, guided by ethical principles, and conducted in a manner aligned with the researcher's understanding of reality and knowledge acquisition.

3.3.6 The rationale for adopting post-positivism.

The unique philosophical foundation underpinning quantitative study is post-positivism according to Creswell (2014). The quantitative study is entrenched in the belief that inquiry should ensure that the research process is objective through systematic observations, answering research questions and the testing of hypotheses (Creswell and Creswell, 2018). This philosophical worldview emphasises the use of empirical evidence to understand and explain a research problem focusing on observable facts rather than subjective analysis (Creswell, 2014). The measure of numerical variables allows the researchers to establish relationships among variables. Post-positivism viewpoint supports the aim of the quantitative study, which is related to a study of human behaviour (Kivunja and Kuyini, 2017). By adopting this philosophical worldview, the aim is to produce reliable and valid results that can be applied to the larger population regarding informal e-waste recycling in Nigeria. Post-positivism position in quantitative research acknowledges the researcher's subjectivity and the contextual factors that can influence outcomes (Fisherman, 2020). It challenges the idea of a singular scientific method and promotes the use of multi-methods to collect multiple data to achieve the research aim and to enhance more robust findings (Creswell and Tashakkori, 2007). On this note, the epistemological assumption of post-positivism in this research is that objective truth can be discovered through empirical studies (Creswell and Creswell, 2018). Therefore, the truth can be uncovered by systematic data collection and analysis. This study's axiological component helps minimise biases by adhering to established research methodologies and processes (Zaidi and Larsen, 2018). The ontological components held that there are uniformities and patterns in the population of this study and can be recognised and explored through empirical measurements (Creswell and Plano Clark, 2007). The methodological assumption for quantitative study in the adopted philosophical worldview is obvious. These assumptions according to Creswell and Creswell (2018), are the use of quantitative data, answering research questions, hypotheses testing, controlled experiments, and systematic observation. However, in this research quantitative data with multiple

perspectives regarding health and safety knowledge and practices among informal e-waste recyclers have been collected. Data were gathered from broad perspectives to enhance the understanding of the research problem. The data were collected on multiple dimensions such as health knowledge, awareness, practices, safety behaviour, safety climate, and quality of work life. A comprehensive analysis of the different sets of quantitative data is envisaged to provide an in-depth understanding of the research problem. It is expected that the findings will stimulate policy realignment as well as engage relevant stakeholders towards capacity building aimed at the improvement of workplace safety and health and the prevention of potential hazards and exposure inherent to improperly managed e-waste in Nigeria.

3.4 Research Design

As discussed earlier in 3.2, three broad approaches, also known as frameworks, give direction to research. On the other hand, research designs are specific plans that outline the details of how the research study will be conducted. Including the specific steps, procedures in data collection, the timing of the data collection, methods of analysis and interpretations that will be employed to address the research questions and implement the objectives of the study (Creswell and Creswell, 2018). Research designs present the direction in forms of qualitative, quantitative and mixed method approaches in which an inquiry is rooted (Creswell, 2014). While the three major research designs stand out, within these broad categories of research designs, there are several specific types of designs that researchers commonly adopt. The overview of some of the common types of research designs within each of the broad designs is highlighted below.

As Creswell (2014) described, qualitative research designs are systematic approaches employed to investigate and gather an in-depth understanding of the research problem. It adopts the exploration and interpretation of subjective meanings of the issues being investigated rather than just quantifying them (Denzin and Lincoln, 2011; Creswell, 2014). The common designs associated with qualitative research according to Saunders et al. (2019) are action research, case study research, ethnography, grounded theory and narrative inquiry. It is also feasible for researchers to adopt more than one design in their study. A concise overview of select research designs is presented below in Figure 3.2.

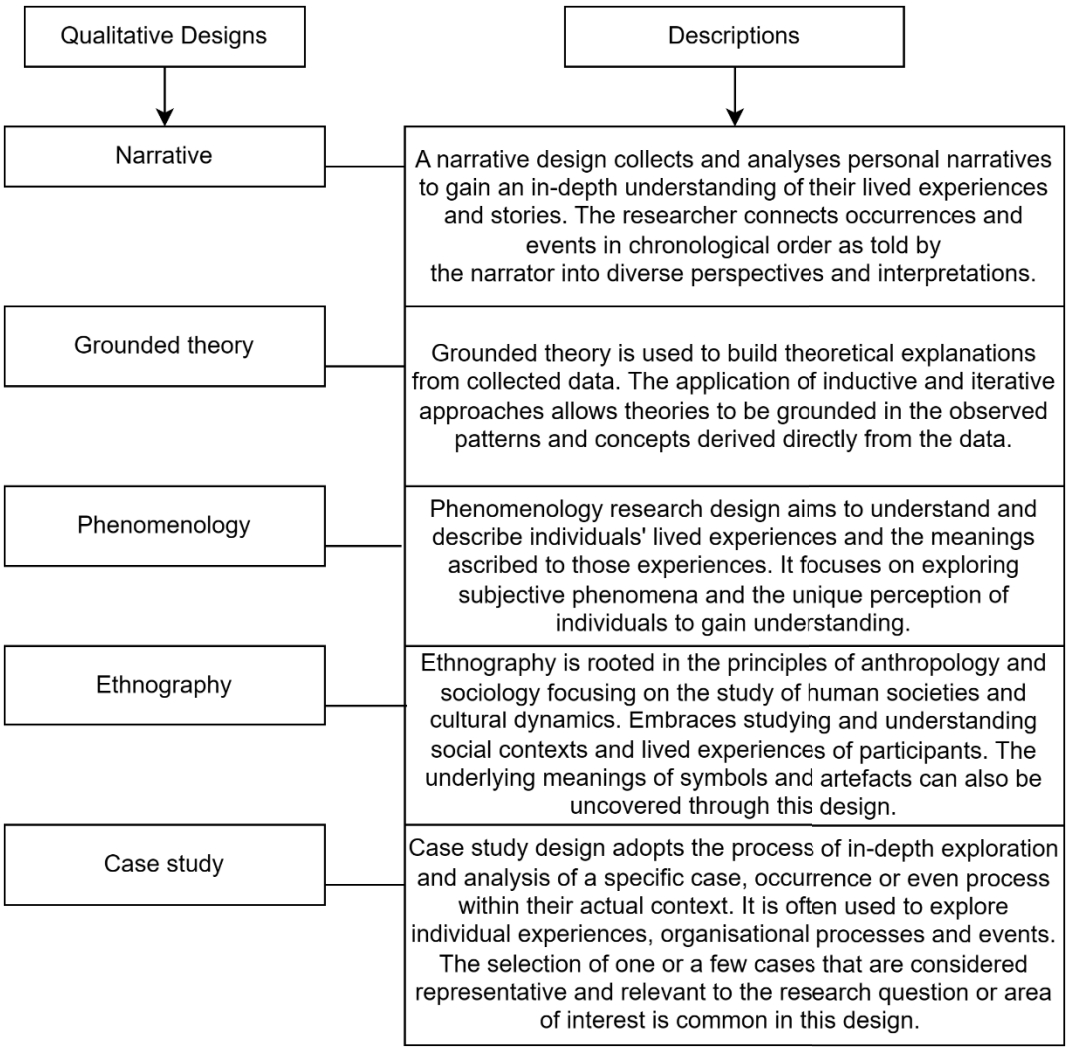

Figure 3.2: Overview of Select Qualitative Research Designs (Sources: Creswell and Creswell, 2023; Saunders et al., 2019; Bryman, 2016)

Quantitative research, broadly categorised into experimental and non-experimental designs, prioritises numeric data (Souza et al., 2007; Khaldi, 2017). Experimental designs, characterised by the researcher's active intervention, facilitate variable manipulation and control, enabling precise examinations of cause-and-effect relationships. In contrast, the present study aligns with the non-experimental designs which focus on participant insights without variable manipulation, striving to discover associations, identify relationships and patterns, and compare variables (Souza et al., 2007). Notable designs within quantitative research include true experimental, quasi-experimental, survey, and correlational. A brief description of them is highlighted in Figure 3.3.

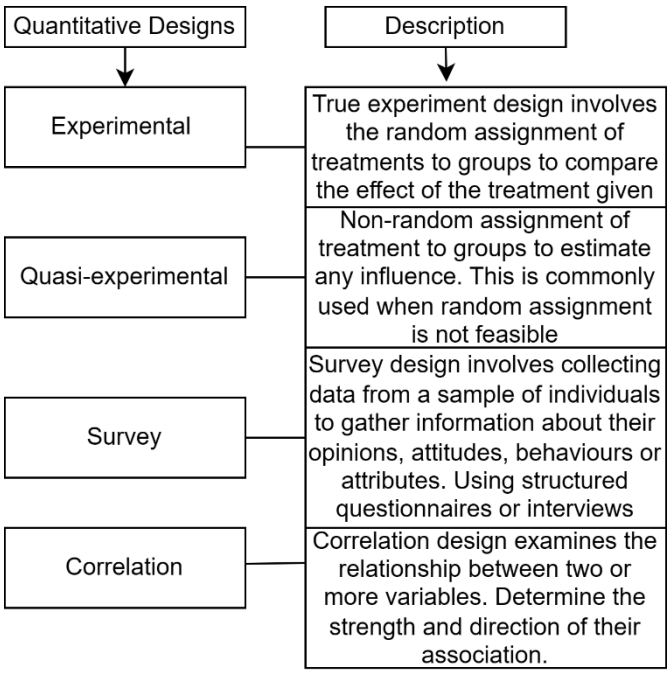

Figure 3.3: Overview of Select Quantitative Research Design (Sources: Creswell and Creswell, 2023; Saunders et al., 2019)

Saunders et al. (2019, p181) described mixed method as a "multiple methods research that integrates the use of quantitative and qualitative data collection technique and analytical procedures in the same research project". The use of mixed methods has increased and advanced since its emanating in the late 1980s (Creswell, 2014). This method has gained popularity in various disciplines having gone through forms of developmental and procedural stages (Creswell and Plano Clark, 2011; Hesse-Biber and Johnson, 2015), this method gives research a cutting edge when adopted. The researcher is interested in the meaning attached to people's experiences and underlying interpretations of informal e-waste worker behaviour.

Within the mixed methods are typologies for identifying the strategies that can be used in the research design, according to Creswell and Plano Clark (2011). According to Creswell et al. (2003), the four criteria that guide the labelling for identifying the typologies within the mixed method are implementation, priority, integration and theoretical view. These criteria are embedded in the six types of design classified by Creswell et al. (2003) shown in Table 3.1.

Table 3.1: Mixed-method Typologies (Source: Creswell et al., 2003:224)

Design Type	Implementation	Priority	Stage of Integration	Theoretical Perspective
Sequential explanatory	Quantitative followed by qualitative	Usually quantitative; can be qualitative or equal	Interpretation phase	May be present
Sequential exploratory	Qualitative followed by quantitative	Usually qualitative; can be quantitative or equal	Interpretation phase	May be present
Sequential transformative	Either quantitative followed by qualitative or qualitative followed by quantitative	Quantitative, qualitative or equal	Interpretation phase	Present (i.e., conceptual framework, advocacy, empowerment)
Concurrent triangulation	Concurrent collection of quantitative and qualitative data	Preferably equal; can be quantitative or qualitative	Interpretation phase or analysis phase	May be present
Concurrent nested	Concurrent collection of quantitative and qualitative data	Quantitative or qualitative	Analysis phase	May be present
Concurrent transformative	Concurrent collection of quantitative and qualitative data	Quantitative, qualitative, or equal	Usually analysis phase; can be during interpretation phase	Present (i.e., conceptual framework advocacy, empowerment)

3.5 The rationale for adopting survey design.

For this study, quantitative research was adopted, offering a robust framework to gather data from substantial sample sizes, ensuring objective measurement and analysis. Such an approach is instrumental in finding relationships, associations, and prevailing trends among variables considered in studies (Creswell, 2014). Survey research design was precisely selected enabling the efficient collection of data from the sampled informal e-waste recyclers through structured questionnaires. According to Creswell and Creswell (2018), survey design mostly exhibits the philosophical assumption of postpositivism. The data collected are usually aimed at describing the characteristics, measuring knowledge, exploring patterns, and

explaining attitudes, behaviours and practices of the population concerning the research problem (Creswell and Creswell, 2018). Moreso, Saunders et al. (2019), stated that the survey strategy supports the collection of data that can be analysed descriptively and inferentially. The authors further explained that the data collected through the survey research strategy can be utilised to infer relationships and patterns among variables. Furthermore, Creswell and Creswell (2018), indicated that survey research design offers valuable means for researchers to address three types of research questions. Specifically, it enables the answering of descriptive questions, which seek to describe the characteristics of respondents about the study. Additionally, survey research facilitates the investigation of relationships between variables. Lastly, this design allows researchers to make predictions about the relationships among variables, enabling the forecast of outcomes or trends over time.

The scope of this research made it relevant to investigate multiple constructs and different dimensions to gather many perspectives. Data from informal e-waste recyclers on their knowledge of health and safety hazards, safety practices, behaviour, training competencies and quality of work life are within the scope of this study. The measure of these diverse aspects is envisaged to provide more insight to better understand the research problem. To answer the research questions, test the formulated hypotheses and achieve the overall aim of the study. Multiple questionnaires were employed, each tailored to capture diverse aspects and perspectives on the research topic and measure different constructs to address the study research questions. The broad scope of this study allows researchers to produce vigorous and reliable evidence that can inform decision-making and contribute to knowledge in the field.

3.6 Research approach - inductive and deductive reasoning

According to Saunders et al. (2019), research studies will at some point involve the application of theory, but they are likely not made obvious in the design. Relatedly, Nardi (2018) stated that theories are a collection of statements designed to provide explanations for various occurrences in our environment. The choice of reasoning approach in research depends on the degree to which the study focuses on testing existing theories and verifying or constructing new ones (Creswell and Creswell 2018; Saunders et al., 2019).

The reasoning approach in research refers to the systematic and logical process used to draw conclusions and derive knowledge from obtained data (Creswell and Creswell 2018).

Reasoning approaches are inherent to various aspects of the research process, including formulating research questions, study design, data collection, analysis and interpreting findings (Saunders et al., 2019). They provide a structured framework for drawing valid and reliable conclusions from the collected data. Reasoning approaches are precise during the discussion of findings and conclusions in research (Saunder et al., 2019).

Deductive and inductive reasoning are the two primary reasoning approaches frequently employed in research (Bryman, 2016; Creswell and Creswell 2023). Deductive reasoning is initiated with a theory, generates either hypothesis or research questions or both and then proceeds to test them. The research structure is predesigned and followed logically to arrive at a conclusion, this is also referred to as a top-down approach. Deductive reasoning enables researchers to draw conclusions and verify hypotheses based on empirical facts (Bryman, 2016). Creswell (2014) stated that the deductive research approach is compatible with quantitative research. In contrast, the inductive approach seeks to develop a theory that explains the phenomenon by starting with observation or pattern, deriving research questions and then presenting a theory based on that (Bryman, 2016). The inductive approach is more compatible with qualitative research where there is a need to understand the inclinations and key context in the data collected to generate a theory (Creswell and Creswell, 2018). This direction of reasoning is referred to as the bottom-up approach. However, Creswell et al. (2003), opined that both inductive and deductive reasoning are suitable in mixed method research, and this is based on the sequence of the mixed method. A deductive reasoning approach is adopted for research where the study builds up on a determined conceptual framework (Creswell and Plano Clark 2018). The conceptual framework is developed based on existing theories and models to outline the key concepts, and variables that were considered in the study. The deductive approach begins with a theory, generates research questions, formulates hypotheses and then designs the research process to gather evidence to support or counter them (Saunders et al., 2019). In this study, the researcher has identified relevant existing theories and models and formulated a conceptual framework and research questions. The Health Belief Model (HBM) and Social Identity Theory (SIT) were adopted as theoretical frameworks to underpin the conceptual framework in this study. Quantitative data were collected based on the variables identified to answer the research questions and test formulated hypotheses (Conceptual Framework introduced in Chapter 2).

The findings will provide further understanding and contribute to the existing knowledge in the field of study. A graphic illustration of the deductive approach adopted in this research is presented in Figure 3.4 below.

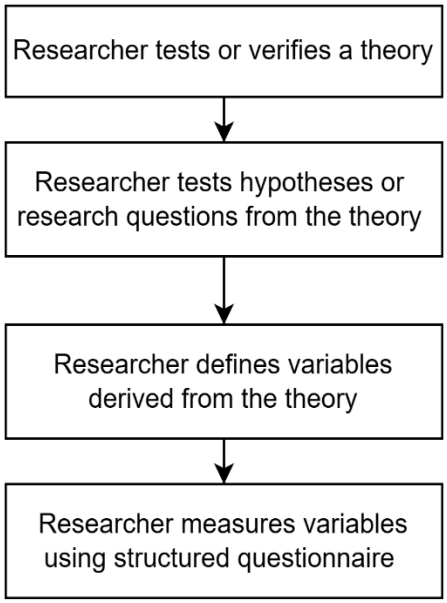

Figure 3.4: Deductive Approach Applicable to this Study (Source: Creswell and Creswell, 2023:62)

3.7 Research strategy

The research strategy refers to the plan that the researchers follow to address their research aims and objectives (Johannesson and Perjons, 2014). The selection of the research strategy is dependent on the type of the research problem and the research questions.

This research adopted multiple survey questionnaires approach due to the suitability to achieve the research objectives. To achieve the research objectives, answer the research questions and test formulated hypotheses, three different survey questionnaires were used. The use of a quantitative survey has been found a suitable approach in this area of study (Nuwematsiko et al., 2021). The Conceptual framework for this study supports the use of survey questionnaires to collect data. Creswell et al. (2018) described a survey research strategy as the type that allows the collection of data in a research study that seeks descriptive questions, the relationship among variables and the predictive relationship between variables

of a defined population. Suitable for the collection of data from a large sample, surveys are designed to gather specific information from participants in a more structured approach. The data collected from surveys are easily quantified, analysed and summarised with statistical methods (Fowler, 2013; Babbie, 2016; Saunders et al., 2019)

3.7.1 Time horizon

According to Saunders et al. (2019), an important consideration in research is the timing of data collection, which can be categorised into two main types known as cross-sectional and longitudinal studies. The choice between these different time frames depends on the nature of the research and the allotted time for the study to be completed. Cross-sectional studies are designed to gather data within a specific period. Studies in this type of approach usually aim to obtain data from or gather pieces of evidence on a research problem from different participants or a sampled group at one point in time (Saunders et al., 2019). This approach is particularly useful when researching characteristics, behaviours, attitudes and opinions that are relevant to a specific moment or period. On the other hand, longitudinal studies involve the collection of data over an extended period. Studies in this category, monitor participants or the sampled group over time and collect repeated data from the same participants over a prolonged duration (Saunder et al., 2019). This allows the researcher to observe changes, trends and developments that occur within the studied population. Longitudinal studies enable a deeper understanding of how variables may have evolved or interacted over time, providing insights into the research problem under study. In the present study, the data were collected at one point in time, and this makes it a cross-sectional approach.

3.7.2 Sampling strategy

The choice of sampling strategy is fundamental for research accuracy and validity. According to Onwuegbuezie and Collins (2007), while there are notable advantages to probability sampling in settings where the population is known and small, non-probability sampling becomes a compelling choice under certain conditions. Specifically, when the population size is unknown or complex and it is difficult to draw random sampling, non-probability sampling is beneficial (Etikan et al., 2016). This technique is informed by availability, peculiar subgroup characteristics, and the informed judgement of the researcher. Consequently, given certain

research settings and objectives, non-probability sampling offers a judicious approach to sample selection.

The target population of this study is all informal e-waste workers (scavengers) in Nigeria by which the findings of the study will be generalised. The total number of the population is indeterminate in terms of definite figures due to a lack of primary data in the public domain based on this, the non-probability sampling was adopted for this study. Nigeria has 36 States and a Federal Capital Territory, to collect data that is more productive, purposive sampling was adopted and Lagos state is selected as the sample population. Lagos State is the heart of commerce and industry and the most populated state in Nigeria (Lagos State Government 2020). Lagos State is a Port city that accounts for 70% of total national cargo freight and has the largest markets in Nigeria (Lagos State Government 2020). The Two Ports in Lagos have been identified as the main entry point for Used Electrical Electronic Equipment into the country as reported by Odeyingbo et al. (2017). Samples were selected from two notable sites, namely Alaba International Market, and Ikeja Computer Village since they share the same characteristics. Alaba International market is the largest electronic and electrical market in Nigeria characterised by many sellers and buyers of second-hand electrical and electronics from all over the country (Ogubgbuyi et al., 2012; Awoniyi, 2016) and on the side are large-scale informal recycling activities. Ikeja Computer Village is the biggest market and hub for used and new information and communication technology (ICT) devices and accessories in Nigeria (Ogungbuyi et al., 2012). There is a huge generation of e-waste and recycling activities in these markets. On this note, purposive sampling was used to collect data to achieve the research objectives and answer the research questions.

3.7.2.1 Sample

Based on the unavailability of primary data for the total number of e-waste Scavengers working in the sector held in a public database, the sample size for the quantitative study was determined using Fisher's formula for estimating simple proportion and an estimate for minimum sample size was applied (Naing et al., 2006). For adequate representation and to enable the generalisation of the findings, participants are estimated at 385 (Proposed n = 385) for studies 1, 2, and 3. (Appendix V Fisher's formula).

Participants were selected purposively due to the homogeneity characteristic of the sampling unit that is relevant to this study (Buelens et al., 2018). Homogenous sample refers to the degree of similarity in a group concerning certain relevant attributes and characteristics. The sample in this study shares the same characteristic (e-waste scavengers) from two notable sites in Lagos, Alaba International Market and Ikeja Computer Village where a huge generation of e-waste and the presence of informal recycling activities takes place. Participants included in the study were specifically selected to meet the criteria of being aged 18 years or older and having a minimum of one year of experience working in the sector. This age requirement ensured that the participants were adults who could provide informed consent to engage in the research. Furthermore, the criterion of one year or more of sector experience was to ensure that the participants had an adequate level of experience and understanding of the processes of informal e-waste recycling and could identify challenges. By including participants who met these specific eligibility criteria, the study aimed to gather insights and perspectives that would contribute to the fulfilment of the research objectives.

3.8 Data collection methods

Data collection methods are fundamental in research as they determine the approach to gathering concepts and how they will be measured thus establishing the validity and the reliability of the results (Nardi, 2018; Saunders et al., 2019). In addition, Bryman (2016) asserts that concepts form the initial elements of theories and are central to the research process. These concepts can take the form of dependent or independent variables and need to be quantified for measurement in quantitative research (Bryman, 2016). To measure the concepts there is a need to have indicators which will make them easily measured (Nardi, 2018). These indicators can be developed with a single question or a set of questions that will take the form of a questionnaire (Bryman, 2016). Three sets of questionnaires were developed to collect data from informal e-waste recyclers for the study. The three questionnaires have been labelled as Study 1, Study 2, and Study 3 (Figure 3.5) for easy identification and reference in this research. The survey instruments gathered sociodemographic data alongside sets of additional items designed to assess the variables considered within the study. One set of questionnaires comprised a 5-point Likert scale and dichotomous questions, and the other two sets were Likert scale questions. The Likert scale

questions allowed the informal e-waste recyclers to express their level of agreement or disagreement on a given statement, using predefined dimensions as follows- (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree. This presented the measure of participants' opinions and perceptions related to the concept that was measured. The dichotomous questions presented participants with two response options of- 'Yes' or 'No' to gather specific information on the assessed variable. Figure 3.5 below illustrates the study objectives and how they were achieved, indicating the research questions (RQ) and associated hypotheses (H) as indicated in Chapter 1.

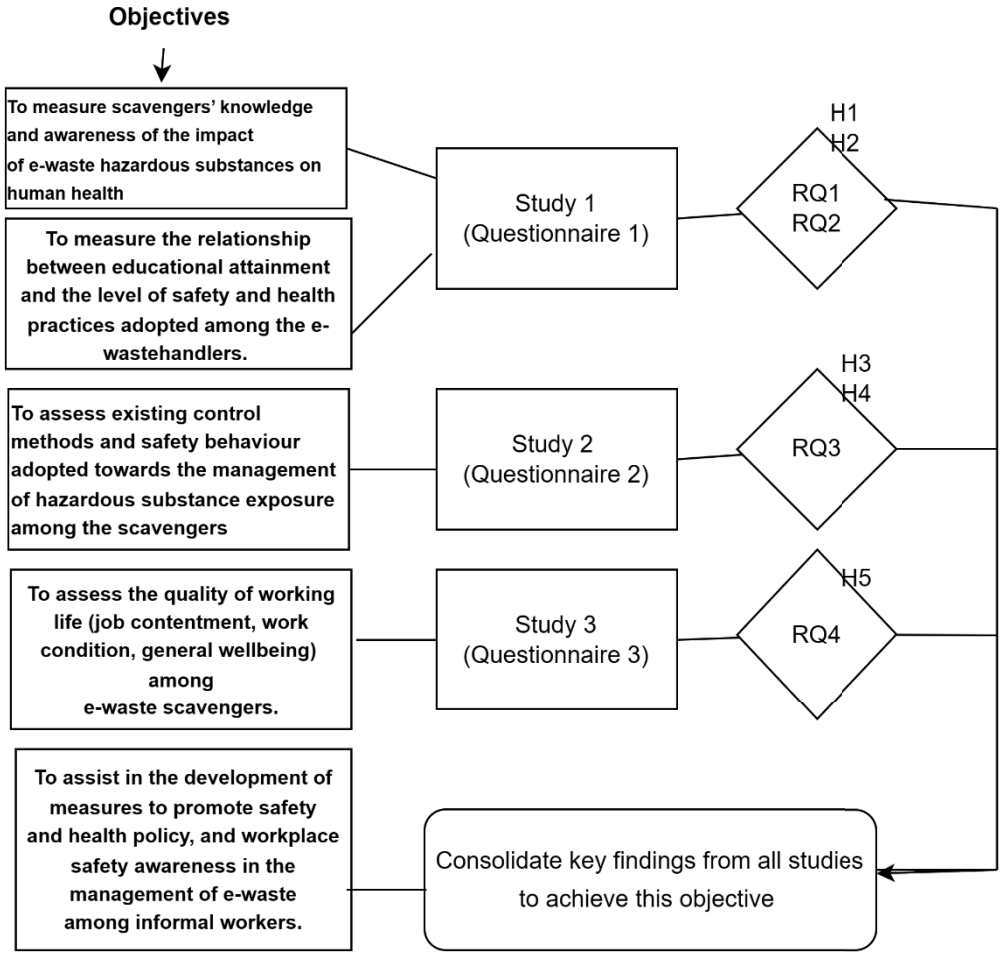

Figure 3.5: Study objectives, associated questionnaire and research questions

3.8.1 Pilot test

At the early stage of the data collection phase, a pilot test was conducted to ensure the reliability and validity of the research study. A target was set to receive 25 responses for each questionnaire for each study during the pilot, following the same procedures planned for the main study, and this target was achieved. The purpose of this pilot test was to assess the research questionnaires and methods of administration and to make any necessary improvements before implementing them on a larger number of participants (Creswell and Creswell 2018; Saunders et al., 2019). During the pilot test, potential issues related to the study design and participant recruitment process were identified. Given the informal nature of the work and working environment of the research sample, it was crucial to address any limitations and challenges that might arise in the study. By conducting the pilot test, the researcher was able to identify and address these potential issues, ensuring that the main data collection phase would be conducted effectively. The length of time for completing questionnaires was noted and adjustments were made by allowing the participant more time at their convenience to complete each of the questionnaires. The need for simplified instructions that provide clear guidelines for understanding the participant information sheet was learned and was provided.

The findings and insights gained from the pilot test allowed the researcher in consultation with and input of the supervisor's expertise to refine and enhance the research instruments and procedures. The acknowledgement of the necessity to employ multiple languages for effective communication intensified during the pilot phase. Consequently, participants were engaged in English, Pidgin English, Yoruba, and Hausa, aligning with their language preferences. This process of testing and refining ensured the overall quality and rigour of the research study. It also instilled confidence in the researcher that the data collected would be reliable and valid, therefore leading to meaningful results.

3.8.2 Study one (Questionnaire 1)

This quantitative study measures scavengers' existing knowledge and awareness of the impact of e-waste hazards on human health. The questions in the questionnaire were learnt from other similar studies (Ohajinwa et al., 2017; Okeme and Arrandale 2019) and were subjected to review by the study supervisor an expert in this area of study.

A structured survey questionnaire (Appendix II) was used to obtain socio-demographic variables such as age, gender, educational status, income level, training received, work shift type, income level and smoking habits. This study collected data on various attributes related to the knowledge of hazardous substances present in e-waste and their potential health effects on both humans and the environment. The data also encompassed participants' awareness regarding the harmful consequences of exposure to these hazardous substances during the recycling process, along with their safety practices. The initial section of the questionnaire sought sociodemographic information about age, gender, educational attainment, years of professional experience, type of training received, work shift schedule, estimated daily earnings, and smoking habits. The second section of the questionnaire is structured in 5-point Likert-type items and dichotomous forms. The second section of the questionnaire assessed participants' knowledge of hazards associated with informal e-waste recycling, their awareness of associated health risks, as well as their occupational health and safe handling practices. Hard copies of the questionnaire were administered with the help of two trained research field assistants to cover a wide range of participants. In total, four hundred copies of the questionnaires were administered to participants across both sites.

3.8.3 Study two (Questionnaire 2)

This survey measured participants' existing control, safety awareness, training and safety behaviour. The questions in the questionnaire (Appendix III) were informed by the Nordic Safety Climate Questionnaire (NOSACQ-50) which is a structured questionnaire used to measure safety climate in organisations. The questionnaire has been used in other workplace settings in Nigeria as a tool to diagnose occupational safety climate and evaluate safety climate interventions and the outcome has helped advance tangible outcomes (Moda et al., 2021a). However, the adoption of the questionnaire was not feasible considering that the study took place in an informal workplace setting. Relevant question items that aligned with the research objectives and concept were identified and therefore adopted for the population under study. Questions such as "We who work here feel safe when working together".

The first section of the questionnaire gathered sociodemographic information such as age, gender, educational status, income level, training received, work shift type, income level, and smoking habit. The other sections were structured in 5-point Likert-type items to collect data

on concepts around general safety climate, safety awareness, safety training and safety behaviour from the participants.

3.8.4 Study three (Questionnaire 3)

This questionnaire (Appendix IV) aimed to identify possible measures that can help improve the quality of work life among e-waste scavengers. The work-related quality of life (WRQoL), which is an evidence-based measure of the quality of working life for use in planning interventions, monitoring workforce experience and assessing the effect of workplace change (Moda et al., 2021b) was considered. However, it could not be fully adopted due to the informal workplace settings and the characteristics of the study population. Relevant questionnaire items that are consistent with the research objectives and research design and appropriate for the population under study were then considered. The first section sought the socio-demographic information of the respondent, the next section consisted of 5-point Likert scale-type questions designed to assess aspects of participants' work experiences and how they feel about their job, work environment, occupational stress and overall general well-being. The measure of these perceptions is needed to determine their quality of work life.

3.8.5 Questionnaire administration

This research employed a careful approach to the administration of questionnaires to informal e-waste recyclers, considering the unique nature of the study population. Initial challenges included a lack of trust, language barriers, and the refusal of access to potential participants. Multiple visits were made to the sites to establish rapport with the informal e-waste recyclers. Based on the scope and the objectives of the research, 3 multiple questionnaires were administered to the same participants to gather comprehensive data for the research study. Hard copies of the questionnaires were administered for data collection. A face-to-face approach was employed with the assistance of two trained research assistants. Virtual support from the primary researcher ensured consistency in the administration process.

The research field team met with the local trade union at the site location. The research flyers and participant information sheets were presented to the trade union members, explaining

the research purpose. Access to other prospective participants was gained after the members of the trade union fully understood the purpose and intention of the research. The trade union explicitly stated that no pictures of any form should be taken during the study and this was duly adhered to. Coercion was strictly avoided, and participants were given sufficient time to respond to questionnaires. Participants were approached in Pidgin English, Yoruba, and Hausa, based on their language preferences. Some terminologies were broken down into simple language to enhance participants understanding and facilitate their engagement with the questionnaire. Literate participants completed the questionnaires independently, while oral explanations were provided to non-literate participants to enable them to indicate their own opinions. Data was collected from 395 participants which is 2.6% higher than the proposed minimum sample of 385. Three hundred and forty (340) respondents were sought from Alaba International Market being the largest site for recycling activities. In addition, 55 were approached at Ikeja Computer Village, ensuring a good representation of the informal e-waste recycling community. Data collection was over the period from January to October 2022. It was inputted into the Jisc online surveys provided by the university to enable numerical analysis with SPSS (Statistical Package for Social Sciences).

3.9 Data analysis

Data was analysed using IBM SPSS Statistics for Windows (version 27) provided by IBM Corporation (2020). Statistical techniques were applied to the collected data to address research questions, test the proposed hypotheses, and provide more understanding of the study. Descriptive statistics, as elucidated by Dancey et al. (2012) and Nardi (2018), outline the inherent characteristics of a dataset, utilising metrics such as mean, median, mode, standard deviation, and frequency distributions. Furthermore, inferential statistics, as highlighted by Dancey et al. (2012), Nardi (2018) and, Saks and Allsop (2019), enable the drawing of conclusions about larger populations from sample analyses.

In the present study, descriptive analysis was initially employed, offering insights into the respondents' sociodemographic characteristics through statistical measures such as frequencies, percentages, means, medians, and standard deviations. These descriptive metrics serve as a foundation for subsequent data analysis and interpretation.

Non-parametric methodologies, primarily the Kruskal-Wallis test, were engaged to determine statistical significance between groups and the significance level was set at $p < .05$. Additionally, factor analysis was implemented to ascertain underlying patterns, while multiple regression and mediation analyses probed relationships and potential mediating factors respectively.

The data analysis is envisaged to aid in obtaining valuable insights from the data collected. Hence, revealing hidden patterns, trends, and relationships among variables identified in the study. Consequently, this will help in drawing meaningful conclusions that will contribute to the existing knowledge in the study of informal e-waste recycling practices and related health and safety consequences on human health and the environment.

3.9.1 Data Normality

Graphical methods, including histograms and Q-Q plots, were utilised to visually assess the data's normality. Although the obtained data hinted at an almost normal distribution and the absence of explicitly extreme outliers was noted, the visual cues from the Q-Q plots and the histogram distribution suggest near-normality (Pallant, 2020). Due to the non-normal distribution of the data, a nonparametric test was employed to ensure robust and valid statistical conclusions (Harpe, 2015).

3.9.2 Validity and reliability

Demonstrating the reliability and validity of a questionnaire helps to prove the quality of the research. Singh (2017) supported other studies that indicated that reliability and validity help to measure the accuracy and consistency of research instruments (Kline, 2000; DeVellis, 2012).

Cronbach alpha is a measure of the reliability of questionnaire items and the strength of their consistency (Cronbach,1951). The higher the value of alpha the more the items are related while Cronbach's alpha of 0.7 and above is regarded as acceptable, less than 0.5 is unacceptable. Cortina (1993) expressed that it should be used with some level of attentiveness (Singh, 2017), as high Cronbach's alpha is not a score as they could be as a result of redundant items in the measuring instrument (Ritter, 2010). When there are fewer items or a short scale it could be difficult to get a reasonable Cronbach alpha, other authors also suggest that an alpha of 0.5 is acceptable reasonably (Field, 2009; Dall'Oglio, 2010). When Cronbach's alpha is low, it is appropriate to report the mean inter-item correlation of ranges between 0.2 and 0.4 (Briggs and Check, 1986) especially when items are few. Furthermore, Clark and Watson (1995) recommended a mean inter-item correlation between 0.15 and 0.5 as adequate for all items. Reliability tests for dichotomous items were obtained with the Kuder-Richardson KR-20 test, which is an appropriate test for dichotomous items and is interpreted as Cronbach's alpha (Singh, 2017).

To test for the validity of the questionnaires, the Pearson product moments validity test was adopted. It uses the principle of correlating each questionnaire item to evaluate its strength and validity (Masson et al., 2003). It involves calculating correlation coefficients between the questionnaire items and a criterion measure. The coefficients are interpreted to assess the strength and direction of the relationship. The critical table is then used to determine the statistical significance of the correlations by comparing them to the cut-off values. The rule of thumb is if the correlations (obtained value) exceed the critical values, it suggests a significant relationship, supporting the validity of the questionnaire items. Equally, if the correlations fall below the critical values, a review of the items may be necessary. The process considers the specified level of significance, sample size, and equivalent critical values to make informed decisions about the validity of the questionnaire items (Syed-Abdul et al., 2019). The critical table provides cut-off values for different sample sizes and desired levels

of significance, in this study, alpha is set at 0.05. By comparing the obtained correlation coefficients to the corresponding critical values, it can determine if the correlations are statistically significant or not. The values closer to 1 indicate a stronger positive correlation, while values closer to -1 represent a stronger negative correlation. A correlation value of 0 indicates no linear relationship between the variables.

3.9.3 Ethical approval

Ethics in research refers to the set of principles, values and guidelines that guide research activities (Bryman, 2016; Saunders et al., 2019). The principles are enshrined in values and guidelines ensuring that research is carried out responsibly with respect for the rights and the well-being of all involved. Participants should be duly informed about the purpose, procedures and potential risks and benefits of the research. This process ensures that there is honesty and transparency. An additional value of research ethics is to ensure that vulnerable people are not unfairly targeted and exploited. The principle of research ethics ensures that researchers respect participant's dignity and privacy and guarantee the confidentiality of the information collected, including the responsible handling of personal information if given (Saunders et al., 2019). The conduct of the research was guided by the University's ethical guidelines.

The study received ethical review and approval from the MMU Faculty of Health and Education ethics committee (Project number: 33879) on 12/12/2021. Participants were fully informed about the background and purpose of the study stated in the participant information sheet and the process was explained to them in Hausa, Yoruba and Pidgin English. With some of the participants having limited levels of education, it was pertinent to ensure they have a full understanding that participating in the study is voluntary and that they can opt out at any time. Verbal and written consent of the participants was obtained before the data collection commenced.

Summary

A quantitative methodological approach is adopted. This approach involves the collection and analysis of numerical data to gain objective insights into the health and safety and workplace practices of informal e-waste recyclers. The postpositivist philosophical worldview underpins this approach, emphasising the discovery of objective truths and exploring factors that influence health and safety among informal e-waste recyclers.

The research applies deductive reasoning, starting with an established conceptual framework informed by the Health Belief Model (HBM) and Social Identity Theory (SIT). These theories provide a comprehensive theoretical lens to interpret how health beliefs and social identities influence informal e-waste recyclers' attitudes and behaviours regarding safety practices and health risks. The HBM helps understand recyclers' perceptions of health threats related to their work, including their knowledge and awareness of potential hazards. Additionally, the SIT contributes to analysing the influence of a collective standpoint on safety behaviours among recyclers and in their workplace.

For this study, purposive sampling is employed as the most suitable sampling technique. Informal e-waste recyclers are selected based on specific criteria relevant to the research focus. The data collected totalled 395, exceeding the initially estimated sample size of 385 and successfully involved participants who willingly provided consent to take part in the research. This ensures ethical considerations are met and the participants are respected. Given the research's quantitative nature and its objective to collect data from a diverse range of informal e-waste recyclers, a survey research design was appropriate. Three structured questionnaires are utilised, each designed to collect data on various aspects within the research scope. These questionnaires target different concepts, including health and safety practices, knowledge, awareness and measures of the quality of work life among the recyclers. Data collection takes place at a single point in time, making the research design cross-sectional. Descriptive statistics helped to summarise the main features of the data, providing an overview of the informal recyclers' sociodemographic information. Inferential tests, such as the Kruskal-Wallis test, and multiple regression analysis were applied to determine if there are statistically significant differences, associations and relationships among the observed variables. The subsequent chapter explores the detailed analysis of the collected data.

4.0 CHAPTER FOUR: RESULTS

Kolmogorov-Smirnov and Shapiro-Wilk tests indicated that the data did not pass the normality check. Harpe (2015) contended that while a sizable sample may yield trustworthy outcomes, some parametric tests may exhibit robustness even in the face of normality violations. Ernst and Albers (2017) propose regression in cases with sufficient sample sizes to ascertain the sampling distributions of the regression coefficients. However, Pallant (2020) emphasised the resilience of non-parametric tests against infringements of normality assumptions when juxtaposed with their parametric counterparts. Their independence from stringent normality prerequisites and adaptability to varied data distributions ensure the persistence of analytical rigour and reliability. Such attributes reinforce confidence in deriving significant inferences without undermining statistical significance.

4.1 Study One: Health knowledge, awareness and practices related to e-waste activities.

4.1.1 Reliability test

The results indicate the internal consistency or reliability of three different variables in study one. Cronbach's Alpha (α) for the variable "Knowledge of Health Effects" is 0.764. This value suggests a good internal consistency among the 11 items that make up the variable. A Cronbach's Alpha value above 0.7 is generally considered acceptable for research purposes, indicating that the items in this variable are consistent in measuring participants' knowledge of health effects. Cronbach's Alpha (α) for the variable "Awareness of the Harmful Effect" is 0.594 suggesting a moderate level of internal consistency. Therefore, reporting mean inter-item correlation can offer additional insights when there are few items in a construct, especially when the coefficient alpha value is low (Brigss and Cheeks, 1986; Clark and Watson 1995). The inter-item correlation mean for this construct is 0.33 and is within the value suggested by the authors. Kuder-Richardson Formula 20 (KR20) for the variable "Health and Safety Practices" is 0.576 suggesting a moderate level of internal consistency among the 10 dichotomous items Table 4.1.

Table 4.1: Reliability test results for study 1

Variables	**Cronbach's Alpha (α)**	**No of Items**
Knowledge of Health effects	0.764	11
Awareness of the harmful effect	0.594	3
Kuder-Richardson Formula 20		
Health and Safety Practices	0.576	10

4.1.2 Validity test

The Pearson correlation coefficients measure the strength and direction of the linear relationship between two variables as presented in Table 4.2. For the present study, the correlation coefficients range between 0.175 to 0.721. The values closer to 1 indicate a stronger positive correlation, whereas values closer to -1 represent a stronger negative correlation. A correlation value of 0 indicates no linear relationship between the variables. The critical value (0.104) is used to determine the level of significance for the correlation coefficients. It is based on the significance level (alpha= 0.05) Critical value for a correlation coefficient is typically 0.104 when the degree of freedom is within the range of (350 - 399). The significance level indicates the probability of observing the correlation coefficients by chance alone. A significance level of 0.001 (or $p < 0.001$). Based on the provided critical value and significance level, all the correlation coefficients have a significance level of 0.001, which means they are statistically significant. Therefore, each correlation coefficient is considered valid to measure knowledge of health effects among participants (Table 4.2).

Table 4.2: Validity test for knowledge of health effects (Pearson Validity test summary)

Item No	Pearson Correlation obtained	Critical Value (0.05, Df=350-399)	Significance	Criteria
1	0.721	0.104	0.001	Valid
2	0.699	0.104	0.001	Valid
3	0.610	0.104	0.001	Valid
4	0.467	0.104	0.001	Valid
5	0.323	0.104	0.001	Valid
6	0.603	0.104	0.001	Valid
7	0.643	0.104	0.001	Valid
8	0.512	0.104	0.001	Valid
9	0.496	0.104	0.001	Valid
10	0.175	0.104	0.001	Valid
11	0.256	0.104	0.001	Valid

Table 4.3. presents the Pearson correlation coefficient validity results, with the obtained values exceeding the critical value (0.104) at a significance value of 0.05. This indicates a significant positive relationship between the items, supporting their validity as measures to determine the level of awareness of the harmful effect of exposure to hazardous substances in e-waste during recycling activities.

Table 4.3: Validity test for awareness of the hazardous effect

Item No	Pearson Correlation obtained	Critical Value (0.05, Df=350-399)	Significance	Criteria
1	0.711	0.104	0.001	Valid
2	0.815	0.104	0.001	Valid
3	0.708	0.104	0.001	Valid

Table 4.4 shows the validity test results of the items evaluated using the Pearson correlation coefficient and it was confirmed that the items are valid, with the obtained values exceeding the critical value at a significance value of 0.05.

Table 4.4: Validity test for health and safety practices

Item No	Pearson Correlation obtained	Critical Value (0.05, Df=350-399)	Significance	Criteria
1	0.385	0.104	0.001	Valid
2	0.397	0.104	0.001	Valid
3	0.437	0.104	0.001	Valid
4	0.357	0.104	0.001	Valid
5	0.548	0.104	0.001	Valid
6	0.480	0.104	0.001	Valid
7	0.476	0.104	0.001	Valid
8	0.459	0.104	0.001	Valid
9	0.510	0.104	0.001	Valid
10	0.497	0.104	0.001	Valid

4.1.3. Descriptive summary for sociodemographic variables

Table 4.5 presents the descriptive statistics of the sociodemographic variables in the measure of the knowledge of health and awareness of the harmful effect of exposure to e-waste hazardous substances among e-waste scavengers. 42.8% of the participants in the study are aged below 30 years of age, the majority being males (94.4%) It is noteworthy that 27.6% of the respondents reported having no formal education, while half of the respondents (50.8%) indicated that they had primary education. Only a small percentage (3.6%) of the participants reported having attained tertiary education and 18.1 % indicated that they have secondary education.

The highlight of the distribution of work experience among the respondents indicates that the majority of them possess relatively limited work experience, with a significant percentage of 48% with work experience in the range of 1 to 5 years. Results of the safety training received revealed that 71.8% learn on the job, while only 8.1% are trained by experts. The work shift pattern shows that 80.9% of respondents indicated that they work full shifts (8 hours and above) which could be a result of workload or due to the rudimentary nature of the informal e-waste processing so there is slow workflow. While most of the recyclers work

full-time, the income margin is divergent with 42.5% earning <3000 Naira (2 US Dollars), 46% earning between 3001 and 6000 Naira (between 2 to 4 US Dollars), and 11.5% earning >6000 Naira above. The data reveals that 33.9% of the workers in the sample reported being smokers, 35.4% never smoked and 30.6% had quit smoking.

Table 4.5: Sociodemographic characteristics of participants included in Study 1

	Frequency % (n)
Age Category (Years)	
18-23	18.0 (71)
24-29	24.8 (98)
30-35	21.0 (83)
36-40	19.2 (76)
41-45	12.7 (50)
46-Above	4.3 (17)
GENDER	
Male	94.4 (371)
Female	3.1 (12)
Prefer not to say	2.5 (10)
EDUCATIONAL LEVEL	
No formal education	27.6 (108)
Primary education	50.8 (199)
Secondary education	18.1 (71)
Tertiary	3.6 (14)
YEARS OF EXPERIENCE	
1-5	48.0 (189)
6-10	27.9 (110)
11-15	17.5 (69)
16-20	4.6 (18)
20-above	2.0 (8)
SAFETY TRAINING TYPE RECEIVED	
On-the-job training	71.8 (283)

Trained by an expert. Never had any form of training	8.1 (32) 20.1 (79)
WORK SHIFT PATTERN Full day Half day	 80.9 (313) 19.1 (74)
INCOME LEVEL PER DAY NGN3000 or less NGN3001-6000 More than NGN6000	 42.5 (166) 46.0 (180) 11.5 (45)
SMOKING HABIT Yes No (Never) No (Quit smoking)	 33.9 (134) 35.4 (140) 30.6 (121)

4.1.4. Awareness and knowledge of the impact of safety practices in the workplace among scavengers

Research question 1 specifically focused on understanding the awareness and knowledge levels among recyclers concerning the potential consequences of e-waste hazards on human health. Questions aimed at assessing informal recyclers' knowledge and understanding of the health risks associated with e-waste recycling, their understanding of preventive measures, and their overall conception of the potential impact on human well-being. Descriptive statistical analysis was employed to summarise the responses gathered from the items that measured the knowledge of health effects and hazards on humans. Followed by the summaries of awareness and hygiene responses. Percentages were computed based on the 5-point Likert questions response categories with strongly disagree (SD), disagree (D), neutral (N), agree (A) and strongly agree (SD) to delineate the distribution of participant perspectives. The mean, median and standard deviation of the measure of knowledge and Awareness are (M=3.24, Mdn = 3.27, SD = 0.69) and (M= 3.26, Mdn = 3.33, SD = 0.69) respectively.

4.1.5 Knowledge of health effects and hazards of e-waste

The following descriptive results present the level of knowledge among e-waste recyclers of the health effects and hazards associated with e-waste. Exactly 39.1% of the respondents agreed that e-waste can pollute the environment, with 9.30% strongly agreeing. On the other hand, a substantial proportion (36.8%) together disagreed and strongly disagreed, indicating a lack of awareness and understanding about the environmental impact of e-waste among the respondents. Nearly 36% of respondents agreed that burning e-waste during informal recycling is harmful to human health, with 12.7% strongly agreeing. However, a significant portion (42.9%) disagreed or strongly disagreed, suggesting a low level of knowledge among the respondents. About 47 % of respondents believe there are safe methods for handling and disposal of e-waste in Nigeria while a notable proportion (43.9%) opposed this view. About 43% of the respondents agreed, and 15.4% strongly agreed that using personal protective equipment (PPE) can reduce the health effects associated with e-waste. On the opposite 31.9% of the respondents did not agree that PPE can reduce the health effects of e-waste. Only 53% of respondents know and agree that safety guidance labels are present on EEE appliances, providing information about safe dismantling and disposal methods. The results show that about half of the respondents (50.6%) agreed that heavy metals in e-waste can cause serious health problems, while 39.4% disagreed and the others were neutral in their responses. Precisely 47.3 % of the respondents disagree that “drinking or eating while handling e-waste materials are likely to get harmful materials into our bodies”. Approximately 45% of respondents disagreed or strongly disagreed that smoking cigarettes while handling e-waste can introduce harmful compounds into the body. Approximately (44%) agreed that the use of personal protective equipment can help prevent exposure to harmful compounds. The result shows that around 18% opined that knowledge of sustainable e-waste handling and recycling would not improve their workplace safety and health practices. Conversely as much as (74%) strongly held the view that knowledge of sustainable e-waste handling and recycling would enhance their workplace safety and health practices. (Figure 4.1)

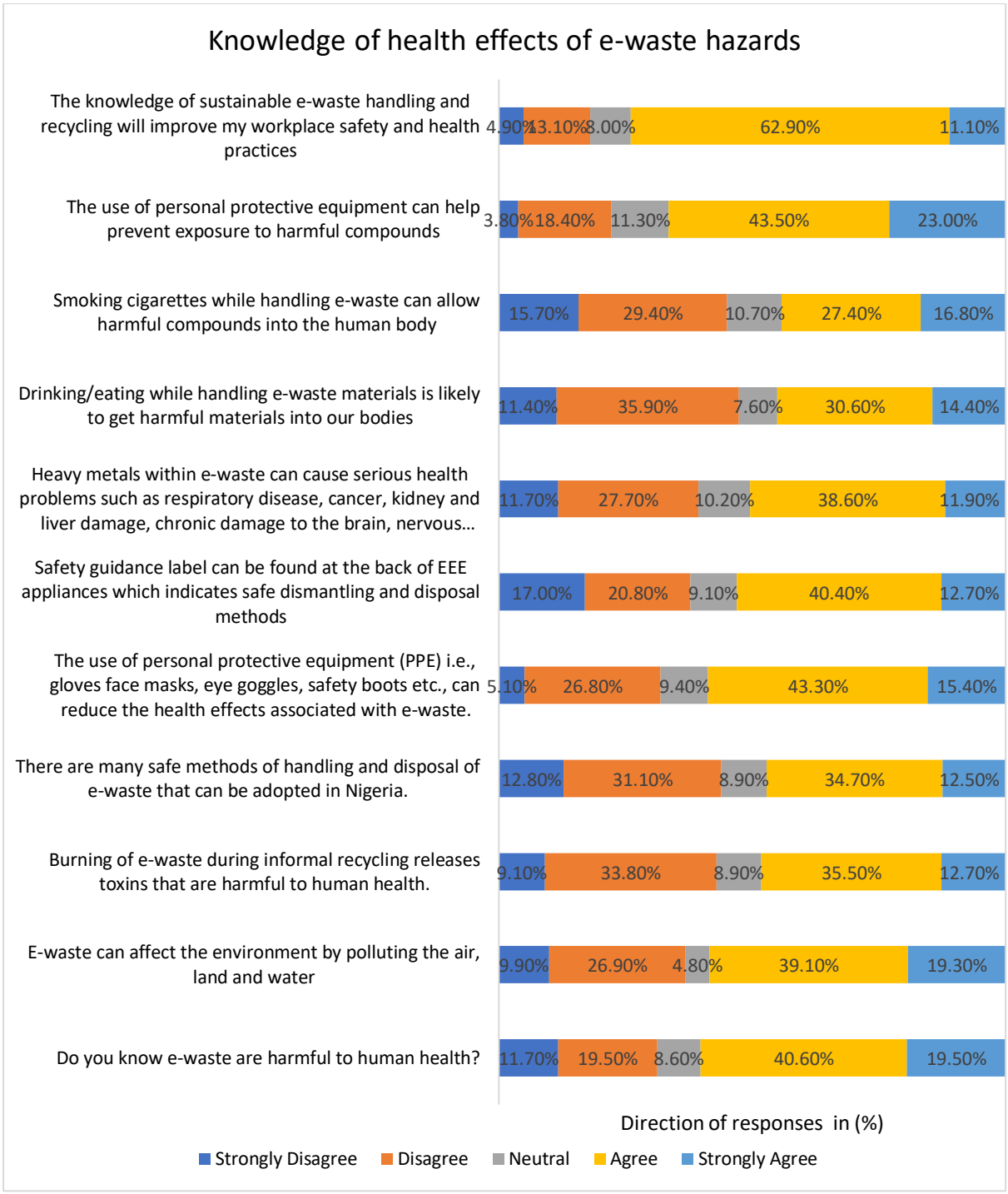

Figure 4.1: Knowledge of e-waste hazards: Survey responses

4.1.6 Awareness of the harmful effects of exposure to hazardous substances in e-waste

Data were collected to assess the level of awareness regarding the potential adverse effects of exposure to hazardous substances in e-waste. Results indicate that a significant portion of respondents (56.80%) agreed or strongly agreed that smoking while burning e-waste products is not safe. This demonstrates a recognition of the potential risks associated with this practice. Yet, a notable percentage (35.90%) either disagreed or strongly disagreed. This suggests varying opinions and a potential lack of awareness regarding the hazards involved. The analysis shows that many respondents (54.80%) agreed or strongly agreed that drinking and eating while handling, dismantling, and burning e-waste can increase the potential for harmful compounds to enter the body while others, a significant portion (41.10%) disagreed indicating potential variation in awareness. Personal protective equipment (PPE) is important to protect the body from chemical and heavy metal poisoning. The results show that 7.50% of the respondents strongly disagreed that PPE is important in preventing chemical and heavy metal poisoning. Precisely 21.10% disagreed with the idea that PPE is important in preventing poisoning and 8.20% held a neutral viewpoint on the importance of PPE. Around 45.60% agreed that PPE is important in preventing chemical and heavy metal poisoning while 7.50% strongly agreed that PPE is important. The variation in the data shows the different levels of understanding and perception of the importance of PPE among informal e-waste recyclers (Figure 4.2).

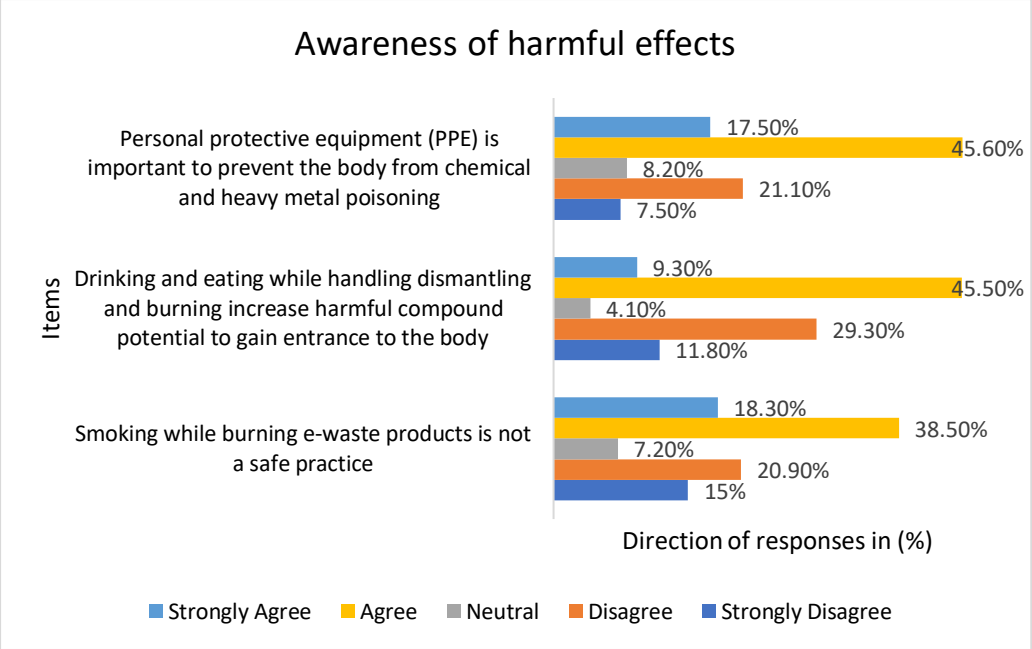

Figure 4.2: Awareness of harmful effects of exposure - Survey responses

4.1.7 Occupational hygiene practices in e-waste handling

The data presented here highlight insights into occupational hygiene practices among recyclers when handling e-waste. Around 57% of the respondents reported washing their contaminated clothes separately each day after working on the site, showing a good measure of maintaining personal hygiene. However, 43.50% indicated that they do not wash their contaminated clothes separately. While 55.60% of the respondents reported having more than one set of working clothes, 44.40% indicated that they only have one set of working clothes. Having multiple sets of clothes can facilitate proper hygiene and reduce the spread of contaminants. Nearly half (48%) of the respondents reported not wearing overalls because they believe they are not important and a slight majority 52% indicated that they consider overalls important and wear them while working. Around half of the respondents (53.40%) reported wearing overalls to protect their skin from cuts and burns while working. while the rest do not wear any protective equipment. A significant proportion (57%) of the respondents reported not wearing eye goggles because they consider them unimportant. Regarding the importance of safety boots, opinions were split, with a slightly higher proportion of respondents (53.30%) acknowledging the importance and opting to wear them while engaging in work activities. The result shows that a majority (63.40%) of respondents do not

wear safety boots while working indicating that they are relying on their perceived caution. A considerable majority of the respondents (72.80%) reported that they regularly burn e-waste parts without using a face/respirator mask. This suggests a potential risk of inhaling harmful substances released during the burning process, which can have adverse health effects. The analysis shows that a significant majority (84.40%) of respondents do not use hand gloves while handling e-waste materials. This indicates a potential lack of protective measures, which can expose individuals to potential risks and hazards associated with e-waste. Figure 4.3.

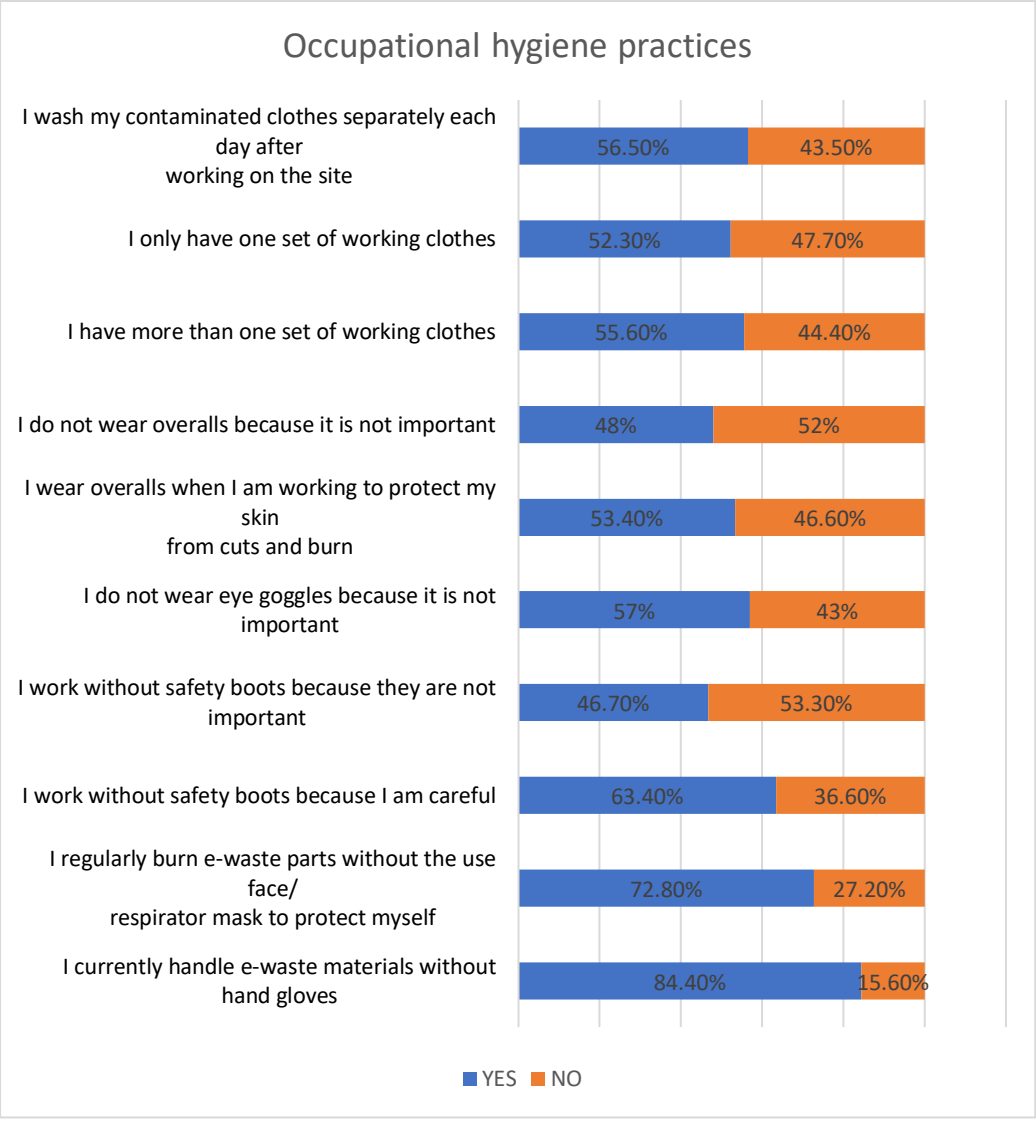

Figure 4.3: Occupational hygiene practices of the respondents.

4.2 Influence of safety training types on scavengers' knowledge of e-waste hazards on human health.

In testing the initial hypothesis of the study, the independent variable considered is the types of safety training, while the dependent variable applies to the knowledge level of scavengers about the effects of e-waste hazards on human health. The distribution of participants according to safety training categories revealed that the majority 72% experienced on-the-job training, 20% had no training, and only 8% received training from specialists (N=394). A Kruskal-Wallis test was conducted at a confidence interval of 95% and a significance level of 0.05 to determine if there are any significant differences between the type of safety training and the respondent knowledge levels regarding e-waste hazards on human health. The test showed that, $H(2) = 2.31$, $p = 0.315$. Given these findings, we fail to reject the null hypothesis, suggesting no statistical difference among the different training types in terms of knowledge of e-waste hazards.

4.3 Education attainment influence on level of knowledge and awareness of e-waste hazards.

This study's second hypothesis investigates the potential relationship between educational attainment and participants level of knowledge and awareness of e-waste hazards and health effects. The independent variable was educational attainment with four categories Figure 4.4. The dependent variables were the levels of knowledge and awareness. The Kruskal-Wallis test results revealed no significant difference between educational levels and knowledge level, $H(3) = 2.959$, $p = 0.398$. Another Kruskal-Wallis test was employed to test if there is a significant difference in educational attainments and level of awareness of e-waste hazards among recyclers. This test found a significant difference in awareness levels across educational attainment categories, evidenced by $H(3) = 10.003$, $p = 0.019$. The Bonferroni post hoc test was conducted to determine the specific pairwise differences in awareness levels among the educational groups. Detailed comparisons between educational levels are presented in Table 4.6 and graphically in Figure 4.5.

The Bonferroni post hoc test further revealed that this significant difference is mainly driven by significantly higher awareness levels among participants with secondary education compared to those with no formal education ($p = 0.043$, Sig. = 0.258) and primary education

(p = 0.008, Sig. = 0.045). However, no significant differences were found in awareness levels between other education attainment pairs (all p-values > 0.05). Therefore, the test suggests that there is a significant difference in awareness levels of e-waste hazards among e-waste recyclers across different education attainments. The Bonferroni post hoc test indicates that participants with secondary education tend to have higher awareness levels compared to those with no formal education and primary education. Other pairwise comparisons did not show significant differences in awareness levels among education attainment groups.

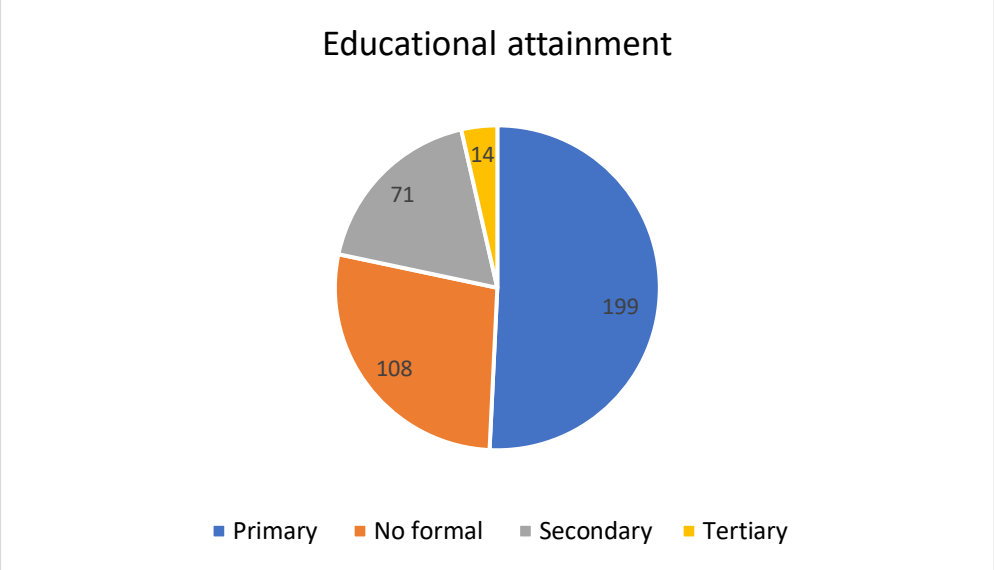

Figure 4.4: Participants educational attainment

Table 4.6: Pairwise comparisons of education attainment

Education levels	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Tertiary-Secondary education	18.579	32.498	0.572	0.568	1.000
Tertiary- No formal education	53.061	31.530	1.683	0.092	0.554
Tertiary-Primary education	59.914	30.713	1.951	0.051	0.307
Secondary education-No formal education	34.482	17.032	2.025	0.043	0.258
Secondary education-Primary education	41.335	15.466	2.673	0.008	0.045
No formal education-Primary education	-6.853	13.314	-0.515	0.607	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. The significance level is .050.

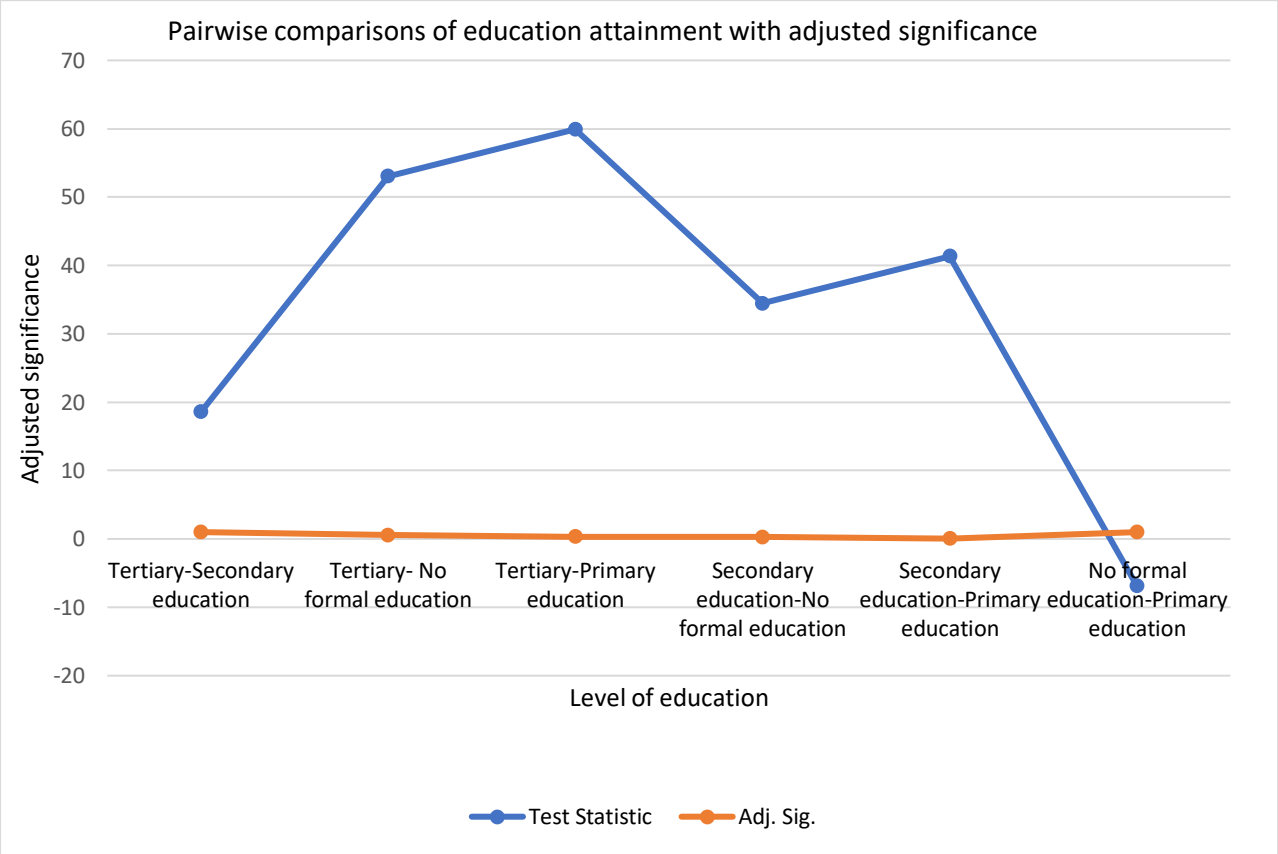

Figure 4.5: Pairwise comparisons of education attainments with adjusted significance.

4.6 Study two: The measure of existing control methods (safety climate), safety awareness, assessment of training acquired and safety behaviour in the workplace.

Research question 3

What are the factors influencing safety climate among informal e-waste recyclers?

Hypothesis

H3: Safety awareness and safety behaviour among e-waste recyclers will have an impact on the safety climate in the workplace.

H4: There is a significant relationship between collective efforts in the workplace and positive safety behaviour among e-waste recyclers.

4.6.1 Reliability and validity

Table 4.7 presents the reliability test summary of Study 2. The result shows the reliability analysis for Cronbach's alpha coefficient for the questionnaire items in the second study. Safety climate, safety awareness and safety behaviour measure 0.673, 0.563 and 0.542 respectively. The obtained Cronbach's alpha values in this research context indicate a moderate level of internal consistency for the variables. It suggests that the items within the scale are moderately correlated and measure the same underlying construct. They may seem lower than desirable (0.7) but the values obtained still demonstrate a reasonable degree of reliability for the instrument and are sufficient for use in this study. However, some authors have cautioned against the subjective cut-off point when using Cronbach alpha to measure reliability, but the type, purpose and other contexts of research should be considered (Cho and Kim, 2015; George and Mallery, 2003; Singh 2017). The low reliability scores may be due to a few question items in a construct. According to Briggs and Check (1986), reporting inter-item correlation means to support reliability due to low Cronbach Alpha reliability is appropriate. This can offer additional insights when there are few items in a construct (Clark and Watson 1995). Thus, Table 4.8 shows the inter-item correlation means of the construct comprising items with α below 0.6.

Table 4.7: Reliability test result summary for study 2

Variables	Cronbach's Alpha (α)	No of Items
Safety Climate	0.673	7
Safety Awareness	0.563	5
Safety Training	0.542	4
Safety Behaviour	0.542	4

Table 4.8: Inter-item mean for items with <6 items and reliability α <0.6.

Inter-Item Correlations							
	Mean	Min	Max	Range	Max/ Min	Variance	No of Items
Safety Awareness	0.200	-0.033	0.547	0.580	-16.603	0.023	5
Safety Training	0.228	0.118	0.319	0.202	2.716	0.004	4
Safety Behaviour	0.231	0.059	0.298	0.239	5.066	0.007	4

The Pearson correlation coefficients were utilised to determine the validity of the items in the construct that measured safety climate, safety awareness, safety training and behaviour. The Pearson correlation coefficients measure the strength and direction of the linear relationship between two variables. In this case, the correlation coefficients range from 0.386 to 0.726. The critical value (0.104) is used to determine the level of significance for the correlation coefficients. It is based on the significance level (alpha= 0.05) Critical value for a correlation coefficient is typically 0.104 when the degree of freedom is within the range of (350 - 399). A significance level of p=0.001 (or < 0.001). Based on the provided critical value and significance level, all the correlation coefficients have a significance level of 0.001, which means they are statistically significant. Therefore, each correlation coefficient is considered valid. Table 4.9.

Table 4.9: Validity test summary for Study 2

Items	Pearson Correlation obtained	Critical Table Value (0.05, Df=350-399)	Sig. Level	Criteria
SafetyClimate				
1	0.569	0.104	0.001	Valid
2	0.514	0.104	0.001	Valid
3	0.595	0.104	0.001	Valid
4	0.623	0.104	0.001	Valid
5	0.585	0.104	0.001	Valid
6	0.599	0.104	0.001	Valid
7	0.509	0.104	0.001	Valid
Safety Awareness				
1	0.386	0.104	0.001	Valid
2	0.615	0.104	0.001	Valid
3	0.647	0.104	0.001	Valid
4	0.726	0.104	0.001	Valid
5	0.591	0.104	0.001	Valid
Safety Training				
1	0.662	0.104	0.001	Valid
2	0.636	0.104	0.001	Valid
3	0.699	0.104	0.001	Valid
4	0.588	0.104	0.001	Valid
Safety Behaviour				
1	0.601	0.104	0.001	Valid
2	0.71	0.104	0.001	Valid
3	0.64	0.104	0.001	Valid
4	0.597	0.104	0.001	Valid

4.6.2 Perceptions of safety climate in the workplace: descriptive results

The mean, median, and standard deviation were calculated for each item in the construct, providing insights into the participants perceptions of the safety climate. The survey items indicated the following results. There are existing safety routines that are in practice in this work environment. The mean score was 2.89 (Mdn = 3.00, SD = 1.196), suggesting a moderate level of agreement with the presence of safety routines. Participants reported that they do all they can to prevent accidents, with a mean score of 3.41 (Mdn = 4.00, SD = 1.120), suggesting a decent level of engagement in accident prevention efforts. Concerning the

ability to deal with safety, participants showed a mean score of 3.01 (Mdn = 3.00, SD = 1.226), suggesting a moderate level of confidence in their capacity to handle safety-related issues at their workplace.

Participants indicated a moderate level of control over decisions affecting their safety at the workplace, with a mean score of 3.06 (Mdn = 3.00, SD = 1.192). The perception of collective efforts to ensure a tidy workplace yielded a mean score of 3.13 (Mdn = 3.00, SD = 1.151), indicating a moderate level of agreement with the collective commitment to workplace tidiness. Participants expressed a relatively high level of agreement that they work together at the workplace to achieve a high level of safety, as evidenced by a mean score of 3.32 (Mdn = 4.00, SD = 1.200). Finally, the perception of feeling safe when working together resulted in a mean score of 3.18 (Mdn = 4.00, SD = 1.214), indicating a moderate level of agreement with feeling safe during collaborative tasks. Overall, the results suggest that the participants perceive a moderate level of safety climate in the workplace, with a collective focus on safety and a sense of security during collaborative work. Table 4.10.

Table 4.10: Safety climate survey items

Safety climate construct			
Survey Items	Mean	Median	Std. Dev
There are existing safety routines that are in practice in this work environment.	2.89	3.00	1.196
We do all we can to prevent accidents	3.41	4.00	1.120
We who work at this site have the ability to deal with safety	3.01	3.00	1.226
I have control over decisions that affect my safety at my workplace	3.06	3.00	1.192
We make collective efforts to ensure that the workplace is kept tidy	3.13	3.00	1.151
We work together at this workplace to achieve a high level of safety	3.32	4.00	1.200
We feel safe when working together	3.18	4.00	1.214

4.6.3 Multiple regression analysis: factors influencing safety climate among e-waste recyclers.

A multiple regression analysis was conducted to evaluate the factors that influence safety climate (dependent variable). Safety awareness and safety behaviour are independent variables. Multiple regression was preferred as the appropriate statistical method for examining the relationship between variables. Major assumptions for multiple regression were assessed before proceeding to ensure the validity and reliability of the results. According to Pallant (2020), It is important to verify the linearity of the variable by examining the scatter plots. The residuals should be normally distributed, and the assumption of constant variance also known as homoscedasticity, which implies that the spread of the residuals is consistent across all levels of the predictor variables are met.

The results show that safety awareness and safety behaviour of informal e-waste recyclers have a significant impact on the safety climate in the workplace. The regression analysis shows that safety awareness and safety behaviour predicted safety climate, F (2, 391) = 37.399, $p < 0.001$, $R^2 = 0.161$. The R^2 shows that the model accounts for 16.10% of the variance in safety climate. Furthermore, unstandardised coefficients (B) were assessed to establish the influence of each of the factors (Safety awareness and safety behaviour on the dependent variable safety climate). H1 assessed if safety awareness will have an impact on safety climate. The result revealed that safety awareness has a significant positive impact on safety climate (B= 2.88, t = 6.484, p=<0.001). Based on this result H1 was supported. In assessing if safety behaviour has an impact on safety climate H2, the result shows that (B= -0.167, t = -3.831, p = <0.001). Indicating a negative impact and thus the hypothesis was supported.

4.6.4 Relationship between collective efforts in the workplace and positive safety behaviour among e-waste recyclers

Mediation analysis was adopted to examine whether the perception of safety when working together partially or fully explains the relationship between workplace collective efforts and positive health and safety behaviour. Within the construct of safety climate, the researcher further explored the relationship among variables with some items. Variable with the following themes was used to conduct a mediation analysis "Working together to ensure a

high level of safety (HS)" on the relationship between "Collective efforts at workplace (WT)" and "Feeling safe when working together (FS)". Figure 4.6 illustrates a diagrammatic representation of the mediation path. The unstandardised coefficients (B), standard errors (Std. Error), and standardised coefficients (Beta) were derived from the regression models.

Firstly, the direct effect of Collective efforts at workplace (WT) on Working together to ensure a high level of safety (HS) shows an unstandardised coefficient (B) of 0.266, with a standard error of 0.047. This effect showed a standardised coefficient (Beta) of 0.278, and the relationship's strength has a ($t = 5.677$, $p < 0.001$). Additionally, the effect of WT on Feeling safe when working together (FS) was established with a coefficient of 0.219, standard error of 0.053 and Beta of 0.206. This relationship was significant with ($t = 4.136$, $p < 0.001$). The combined effect of both WT and FS on HS while accounting for WT, has a coefficient (B) of 0.257, standard error of 0.052, Beta of 0.245, $t = 4.936$, and $p < 0.001$. When the combined effect considered FS, the result shows a coefficient of 0.156, standard error of 0.049, Beta of 0.158, $t = 3.180$, and $p = 0.002$.

To test the significance of the indirect effect in the mediation analysis, Sobel Test was performed to examine the significance of the mediation effect (Sobel 1982). The Sobel test statistic was found to be 2.522 with a standard error of 0.013 and a p-value of 0.012.

The results indicate that "Collective efforts at the workplace" (WT) significantly predict both "Working together to ensure a high level of safety" (HS) and "Feeling safe when working together" (FS). Additionally, "Working together to ensure a high level of safety" (HS) significantly predicts "Feeling safe when working together" (FS). Furthermore, the mediation analysis shows that the indirect effect of "Collective efforts at the workplace" (WT) on "Working together to ensure a high level of safety" (HS) through "Feeling safe when working together" (FS) is significant, as evidenced by the significant Sobel test result (Sobel test statistic = 2.522, $p = 0.012$). These findings suggest that the relationship between "Collective efforts at the workplace" and "Working together to ensure a high level of safety" is partially mediated by "Feeling safe when working together".

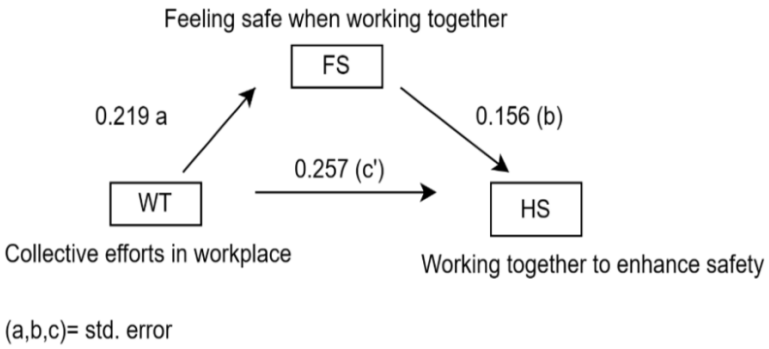

Figure 4.6: Mediation Model Diagram

4.7 Study three: Assessment of the factors that influence the quality of work life among e-waste recyclers.

Research question 4

What factors can improve the quality of work life among informal e-waste recyclers?

Hypothesis

H5: There is a significant relationship between income level and quality of work life among informal e-waste recyclers.

4.7.1 Reliability test

A reliability coefficient of 0.644, was obtained from the construct used to measure the quality of work life among informal e-waste workers. The obtained coefficient indicates a satisfactory level of reliability among the items within the questionnaire and is acceptable in the context of this study. The survey questionnaire encompassed a range of inquiries aimed at capturing various aspects of the e-waste recyclers' work-related experiences and overall well-being. These included a series of questions that sought to assess the indices related to job satisfaction and dissatisfaction, explore the prevailing work environment conditions they encountered, and the occupational stress they faced. Survey items included questions that probe into the dynamics of achieving a healthy home-work balance, and issues concerning their general well-being. By covering these dimensions, the questionnaire aimed to provide a holistic understanding of participants' quality of work life. The alpha level obtained is within

the acceptable range and suitable for the research. This provides confidence that the collected data can be effectively utilised for meaningful analysis and interpretation in the context of this research.

4.7.2 Validity test

Table 4.11 presents the validity summary of the construct employed to measure the quality of work of life among e-waste recyclers. The correlation coefficients range from -0.030 to 0.574. The values closer to 1 indicate a stronger positive correlation, while values closer to -1 represent a stronger negative correlation. A correlation value of 0 indicates no linear relationship between the variables. The critical value (0.104) is used to determine the level of significance for the correlation coefficients. It is based on the significance level (alpha= 0.05) Critical value for a correlation coefficient is typically 0.104 when the degree of freedom is within the range of (350 - 399). A significance level of 0.001 (or < 0.001). Based on the provided critical value and significance level, 18 out of the correlation coefficients have a significance level of 0.001, suggesting that most of the items effectively measure the intended construct and demonstrate the expected relationships with other variables. However, only 1 item did not meet the validity criteria. While it is sometimes common to exclude items that do not meet the validity test from a research instrument (Dewitt et al., 2019), there are circumstances in which it may be necessary to consider including such items. In this case, the question is relevant and has the potential to provide a broader understanding of the research problem. Thus, it will be retained to ensure the broad coverage of the concept being explored with the set of items.

Table 4.11: Validity test summary for quality of work life (Study 3)

Item No	Pearson Correlation obtained	Critical Value (0.05, N= 350-399)	Significance Level	Criteria
1	0.408	0.104	0.001	Valid
2	0.574	0.104	0.001	Valid
3	0.517	0.104	0.001	Valid
4	0.261	0.104	0.001	Valid
5	0.213	0.104	0.001	Valid
6	0.452	0.104	0.001	Valid
7	0.393	0.104	0.001	Valid
8	0.369	0.104	0.001	Valid
9	0.104	0.104	0.042	Valid
10	0.175	0.104	0.001	Valid
11	0.443	0.104	0.001	Valid
12	0.404	0.104	0.001	Valid
13	0.515	0.104	0.001	Valid
14	0.546	0.104	0.001	Valid
15	0.503	0.104	0.001	Valid
16	0.549	0.104	0.001	Valid
17	-0.030	0.104	0.554	Invalid
18	0.220	0.104	0.001	Valid
19	0.363	0.104	0.001	Valid

4.7.3 Analysis of quality of work-life constructs

Table 4.12 presents the individual items in the construct that measured the quality of work life in the survey. Showing 5-point Likert-type questions ranged from strongly disagree (1) to strongly agree (5). The descriptive summary supports the understanding of the general pattern and variability of the responses in the dataset. For example, the first item 'I feel well now' has a mean score of 3.48, indicating that, on average, the respondents' scores fall around that value. The median score of 4.00 suggests that many respondents have a score close to or higher than 4.00. The standard deviation of 1.22 indicates a moderate amount of variability in their responses. The question "My current working hours/pattern suits my circumstances" obtained a mean score of 2.99 suggesting that, on average, respondents reported that their current working hours or pattern fairly suits their circumstances. The median score of 3.00 indicates that the majority of respondents rated their working hours or pattern as neutral or slightly suited to their circumstances. The standard deviation of 1.22

suggests some variability in the responses, indicating that there is a range of opinions among the participants regarding how their working hours align with their situations.

The question "I feel safe using the toilet facilities at work" was answered by 393 respondents. The mean score of 2.73 suggests that, on average, respondents reported feeling somewhat unsafe or uncertain about the safety of using the toilet facilities at work. The median score of 2.00 indicates that many respondents rated their feelings towards the safety of using the toilet facilities as lower than the average. The mean score of 2.78 for the question "I earn enough to sustain me and my family", suggests that, on average, respondents reported feeling that their income is inadequate to sustain themselves and their families. The median score of 2.00 indicates that most respondents rated their income level as below the average in terms of meeting their needs. The standard deviation of 1.29 indicates a moderate amount of variability in the responses.

Table 4.12: Descriptive statistics of quality of work-life constructs

Survey Items	N	Mean	Median	Std.Dev.
I feel well now.	393	3.48	4.00	1.22
I have adequate facilities and flexibilities for me to fit work in around my family life	394	2.94	3.00	1.27
My current working hours/ pattern suits my circumstances	392	2.99	3.00	1.29
I often feel under pressure at work	394	2.91	2.00	1.28
I feel unhappy and depressed	394	2.83	2.00	1.30
I am satisfied with my life	393	3.15	4.00	1.22
Mostly, things work out well for me	393	2.94	3.00	1.31
I work in a safe environment	392	2.94	2.00	1.29
I often feel an extreme level of stress while at work	394	3.55	4.00	1.24
I often take unfinished work home	392	2.80	2.00	1.53

I feel safe using the toilet facilities at work	393	2.73	2.00	1.39
I have access to clean and safe water at work	394	2.83	2.00	1.30
I can give opinions and influence changes in my area of work	394	2.84	2.00	1.24
I am satisfied with my current job	394	2.99	3.00	1.26
The Working conditions are satisfactory	394	2.75	2.00	1.25
I earn enough to sustain me and my family	393	2.78	2.00	1.29
The nature of my job gives me concerns over my health	394	3.12	3.00	1.25
I have a good working relationship with fellow workers on this site	394	3.55	4.00	1.22
I receive adequate training for the work I perform	392	2.70	2.00	1.25

4.7.4 Income level distribution

The income level distribution provides valuable insights into the socioeconomic dynamics within the study population. Providing a baseline for exploring potential associations between income and other variables that were considered in this study. Participants' income level per day was assessed and classified into three categories: NGN3000 or less, NGN3001-6000, and more than NGN6000. Further analysis shows that about 42.50% of the participants reported an income level of NGN3000 or less. This indicates that a significant portion of the participants have a comparatively low income, which may suggest constraints and limited resources to meet their needs. Around 46% of the participants indicated that their daily pay is in the NGN3001-6000 income range. This category represents individuals with a moderate income level. The remaining 11.50% of the participants reported a daily income level exceeding NGN6000.

4.7.5 What factors can improve the quality of work life among informal e-waste recyclers?

The survey instrument used in the Study 3 survey questionnaire, which comprised 19 questions that assessed the various aspects related to the quality of work life, was distributed among informal e-waste recyclers. Firstly, to answer the research question it was necessary to uncover the underlying patterns and commonalities among the variables within the questionnaire. Factor analysis was employed as a statistical technique to identify the patterns and relationships within the variable (Pallant, 2020). Specifically, the principal component analysis method with varimax rotation was applied to identify components that effectively summarise the variables into patterns (Pallant, 2020). This analytical approach allowed for a deeper understanding of the underlying structure and associations within the dataset. Through this procedure, valuable insights were obtained regarding the factors that influence the quality of work life among informal e-waste recyclers. Furthermore, a regression analysis was conducted to investigate the connections that exist among the identified factors. The goal is to investigate how the identified factors influence the quality of work life among informal e-waste recyclers. Through this analysis, valuable knowledge of the factors that have the most significant influence on the quality of work life among the participants will be gained.

4.7.5.1 Exploring patterns and relationships among variables.

The commonalities of the scale were also assessed, and the result shows all commonalities were 0.3 and above. The factor analysis result suggests that the correlation among the components is statistically significant. Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was found to be 0.721, indicating a sufficient sample size for factor analysis. Furthermore, Bartlett's Test of Sphericity was statistically significant, Chi-square (171) = 1465.214, $p < 0.001$, suggesting that the correlation matrix is not an identity matrix, and factor analysis is appropriate. This measure assesses the adequacy of the sample size and the common variance among variables, signifying that the dataset has sufficient strength for conducting factor analysis. The factor analysis yielded five factors that collectively explained 53.037 per cent of the total variation. These factors correspond to components that contribute to the observed variability across the scales. The results revealed the presence of five distinct factors that account for the variation in the data. Factor 1, consisting of 8 items,

was identified as "Job satisfaction". Factor 2, comprising 4 items, represents "General well-being". Factor 3, with 4 items, corresponds to "Occupational stress". Factor 4, comprising 2 items, is related to "Work Environment," while Factor 5, consisting of 1 item, pertains to "Home-work balance". The factor loading table also presented in Table 4.13, displays the strength of the relationships between the observed variables and their respective factors. These factor loadings indicate the extent to which each variable is associated with a particular factor. Higher factor loadings suggest stronger relationships, while lower loadings indicate weaker associations.

While it is commonly prescribed to include multiple items in a factor (Loo, 2002), the single item identified as a factor in the questionnaire essentially captures a significant aspect of the concept of the quality of work life that is being measured. Following thoughtful deliberation, the researcher decided to incorporate it into the study. According to Loo (2002), the inclusion of a 1-item factor should be carefully considered and recognise the
item as a key indicator and should contribute to the understanding of the research problem.

Table 4.13: Factor loading for quality of work life.

Quality of work life items	Factor Loading				
	1	2	3	4	5
Factor 1: Job Satisfaction					
I am satisfied with my current job	**0.69**				
I earn enough to sustain me and my family	**0.64**	0.39		0.32	
The Working conditions are satisfactory	**0.61**				
I can give opinions and influence changes in my area of work	**0.59**				
I am satisfied with my life	**0.58**				
I receive adequate training for the work I perform	**0.54**			0.31	
I work in a safe environment	**0.47**				-0.35
I have a good working relationship with fellow workers on this site	**0.31**		-0.47		
Factor 2: General Wellbeing					
I feel well now.		**0.76**			
Mostly, things work out well for me		**0.67**			
My current working hours/ pattern suits my circumstances		**0.55**			0.42
I have adequate facilities and flexibilities for me to fit work in around my family life		**0.49**		0.45	
Factor 3: Occupational Stress					
I often feel an extreme level of stress while at work			**0.66**	-0.35	
I often feel under pressure at work			**0.65**		
I feel unhappy and depressed			**0.57**		0.52
The nature of my job gives me concerns over my health		-0.31	**0.48**	0.4	
Factor 4: Work Environment					
I have access to clean and safe water at work				**0.72**	
I feel safe using the toilet facilities at work				**0.59**	-0.3
Factor 5: Home-Work Balance					
I often take unfinished work home					**0.8**

4.7.5.2 Exploring factors affecting the quality of work life.

Earlier, factor analysis using the method of principal component analysis has been exploited to identify five components related to Quality of work life. To further explore the impact of these factors on the overall concept, the researcher utilised multiple regression analysis, with an emphasis on the standardised regression coefficient (Beta). The purpose of this analysis is to discover which of the identified factors has the most impact on participants overall quality of work life. The standardised coefficients (Beta) were used to determine the highest contributor to the model. The overall model was statistically significant $F (5, N = 386) = 407637.95$, $p < 0.001$, $R^2 = (1)$ indicating that the predictors (JS, GWB, OS, WE, HWB) collectively contributed significantly to explaining the variance in Quality of Work Life. The standardised coefficients (Beta) indicated the relative importance of each predictor variable in influencing the concept variable Quality of Work Life. Among the predictors, Job Satisfaction (JS) had the highest standardised coefficient (Beta = 0.649), followed by General Well-Being (GWB) (Beta = 0.395), Occupational Stress (OS) (Beta = 0.367), Work Environment (WE) (Beta = 0.248), and Home-Work Balance (HB) (Beta = 0.170). Thus, Job Satisfaction (JS) emerges to be the highest contributor to the model in predicting Quality of Work Life, followed by General Well-Being (GWB), Occupational Stress (OS), Work Environment (WE), and Home-Work Balance (HB). All predictors had statistically significant standardised coefficients with ($p < 0.001$), indicating that they significantly contributed as factors that influenced Quality of Work Life. However, the result indicated that Job Satisfaction (JS) is the highest factor influencing the Quality of Work Life among e-waste recyclers. Table 4.14.

Table 4.14: Regression analysis result: quality of work life

Quality of work life (QoWL)					
Model	B	Std. Error	Beta	t	Sig.
(Constant)		0.002		0.019	0.985
JS	0.420	0.001	0.649	798.089	0.000
GWB	0.211	0.000	0.395	522.351	0.000
OS	0.211	0.000	0.367	496.595	0.000
WE	0.106	0.000	0.248	317.990	0.000
HB	0.052	0.000	0.170	233.065	0.000

Dependent Variable: QoWL. JS: Job Satisfaction, GWB: General well-being, OS: Occupational Stress, WE: Work Environment, HB: Home-Work Balance

4.8 Assessing job satisfaction as the dominant factor and its interplay with other factors in quality of work life.

A stepwise regression process was employed to identify the variables with significant impact for further analysis. This method systematically selects and includes variables based on their significance, ensuring that only relevant and dominant variables are included in the final model for further analysis (Smith, 2018). The dependent variable in this analysis is JS (Job satisfaction) and independent variables (GWB, OS, WE, HWB) were entered or removed in each step. The variables were selected based on p-values. Home-work Balance (HWB) was removed indicating that it was not statistically significant for the model. A further analysis was conducted with the remaining variable.

Multiple regression analyses were conducted to examine the relationships between general wellbeing (GWB), occupational stress (OS), work environment (WE) and Job satisfaction (JS). The model was statistically significant ($F(3, 390) = 44.186$, $p < 0.001$). The R^2 is 0.254, indicating that the independent variables collectively account for 25.4% of the variance in Job-satisfaction. The results indicate that there is a significant positive relationship between general-wellbeing (GWB) and job-satisfaction (JS) ($B = 0.23$, $t = 6.244$, $p < 0.001$), suggesting that higher levels of general-wellbeing are associated with increased job-satisfaction. Similarly, there is a significant negative relationship between occupational stress (OS) and job-satisfaction (JS) ($B = -0.248$, $t = -6.36$, $p < 0.001$), implying that higher levels of occupational stress are related to lower job satisfaction. Additionally, a significant positive relationship was found between work-environment (WE) and job satisfaction (JS) ($B = 0.177$, $t = 6.019$, $p < 0.001$), suggesting that a positive work environment is associated with increased Job-satisfaction. Overall, the result signified that general well-being, occupational stress, and job environment significantly influence Job-satisfaction among e-waste recyclers. Table 4.15.

Table 4.15: Multiple regression analysis - job satisfaction and its interplay with other factors that influence quality of work life.

	Regression Models	B	T	p-value
	GWB → JS	0.23	6.244	0.001*
	OS → JS	-0.248	-6.36	0.001*
	WE → JS	0.177	6.019	0.001*
R^2	0.254			
F (3, 390)	44.186			

*p< 0.05. GWB: General Well-being, JS: Job Satisfaction, OS: Occupational Stress, WE: Work Environment

4.9 Influence of income levels on quality of work life among participants

To test the hypothesis, a Kruskal-Wallis test, serving as an alternative to one-way ANOVA, was employed to assess the potential influence of income levels on the quality of work life among participants. The data identified 3 income level distributions within the group. (<Ngn3000: Ngn3001-Ngn6000: and >Ngn6000).), representing the lower, medium, and higher income levels, respectively. The result revealed a statistically significant difference in quality of work life among the three income levels, *H* (2, 393) = 11.990, *P* = 0.002. Furthermore, the Bonferroni post hoc test to determine which specific income groups differ significantly. Income levels of 3001-6000 and less than 3000 showed a positive Test Statistic of 12.255 (t = 1.005, p = 0.315, sig. = 0.944), indicating no statistically significant difference between the two groups. However, for income levels of 3001-6000 and more than 6000, the test statistic was -64.985 (Std. Test Statistic = -3.461, p = 0.001, adjusted significance = 0.002), indicating a statistically significant difference between the two groups. Similarly, income levels of less than 3000 and more than NGN 6000 displayed a Test Statistic of -52.730 (Std. Test Statistic = -2.793, p = 0.005, adjusted significance = 0.016), signifying a statistically significant difference between the two groups. The result is presented in Table 4.16 and graphically illustrated in Figure 4.7. These results suggest that there are significant differences between these income groups. In other words, individuals with medium-income levels exhibit a significantly different quality of work life compared to those with higher income levels, and individuals with higher income levels also differ significantly from those with lower income levels. This indicates that income level has a significant impact on the quality of work life among informal e-waste recyclers.

Table 4.16: Pairwise income level comparisons: Bonferroni post hoc test

Income level (NGN)	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
3001- 6000 and Less than 3000	12.255	12.191	1.005	0.315	0.944
3001-6000 and More than 6000	-64.985	18.774	-3.461	0.001	0.002
Less than 3000 and More than Ngn6000	-52.730	18.877	-2.793	0.005	0.016

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. The significance level is 0.050.

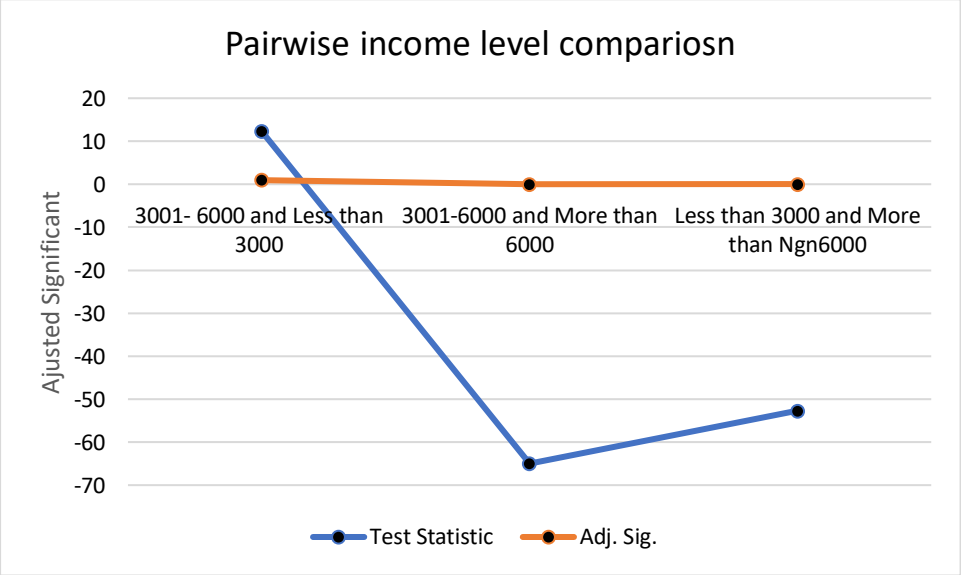

Figure 4.7: Income level comparison chart for quality of work life

5.0 CHAPTER FIVE: DISCUSSION

This study aims to assess health and safety awareness levels and evaluate the quality of work life among informal e-waste recyclers to enhance their occupational health, safety, practice and well-being. Data collection instruments were organised into three sets designated Study 1, Study 2, and Study 3 based on the research scope and objectives. The initial questionnaire evaluated the knowledge and awareness of informal e-waste recyclers regarding the hazards e-waste poses to human health. The second study assessed participants perception of safety practices, safety climate, behaviour, and the training types they have received. The third questionnaire assessed the overall quality of work life experienced by the e-waste recyclers. A deductive reasoning approach and conceptual framework aided in the interpretation and contextualisation of results. The conceptual framework was grounded in the Health Belief Model (HBM) and Social Identity Theory (SIT) to explain the findings of the study. Studies have indicated that potential adverse effects often remain unrecognised, leading many e-waste workers to remain unaware (Yu et al., 2016; Popoola et al., 2019). This lack of knowledge and awareness contributes to inadequate workplace safety practices, subsequently impacting the well-being of the e-waste workers. From the lens of Social Identity Theory (SIT), it becomes possible to understand how the collective identity and group dynamics of e-waste workers can influence their perception of safety and risk. The findings in this study revealed that informal e-waste recyclers are most likely to keep to the group norms which could regard safety practices, driven by a unified identity through improved workplace safety behaviours. An earlier study by Reicher et al. (2010), also noted that shared norms, values and understanding can foster positive behaviours.

On the other hand, the Health Belief Model (HBM) highlights individual health behaviours by focusing on the personal perceptions of the risk posed by a health problem and the benefits of avoiding the risk through better understanding (Rosenstock, 1974). The finding in this study showed the e-waste workers perceptions of susceptibility to health issues due to unsafe practices, and their perception of the severity of potential health issues. By understanding the barriers that prevent workers from adopting safer practices and the cues that can stimulate positive changes. This corroborates with the findings of Lindsay and Strathman (1997), and Rahu and Rodrigues (2020), who have previously adopted the HBM model in the study of recycling behaviour.

5.1 Study One: Health knowledge, awareness and practices related to e-waste activities.

A substantial proportion (42.8%) of the participants was less than 30 years of age and the sample predominantly consisted of males (94.4%). This finding supports the study by Asampong et al. (2015) who asserted that many young people engage in informal e-waste recycling due to limited employment opportunities and economic factors in Ghana. The study by Popoola et al. (2019), which reviewed the heavy metal concentration in the blood of e-waste workers in Nigeria, found that all respondents were males and 56.7% of them were between 21-30 years of age. In addition, Ohajinwa et al. (2017) acknowledged in their study that informal e-waste recycling in Nigeria is dominated by males. Singhal et al. (2021) in their study in India found that 80% of the participants were male and the average age was 30 years. The educational background of the participants offers more insight into their attributes. A significant 27.6% of the recyclers have no formal education, and the majority 50.8% have primary education. This is relatable to other studies where most of the e-waste recyclers' educational attainment mostly ranged from having no education to primary education (Adusei et al., 2020; Singhal et al., 2021). The findings in this study suggest that individuals with low educational attainment are more likely to enter the informal e-waste recycling job and have little or no further opportunity to attain more education.

Regarding work experience, around 48% had work experience ranging between 1 to 5 years. This signals a high turnover rate translating to constant entry of new workers. Safety training types received by the respondents are a concern, indicating a potential gap in attaining formal safety training. The result obtained shows that most of the e-waste workers are trained on the job. The result supports the claim by Fischer et al., (2020), that workers in informal e-waste recycling mostly lack occupational training. This lack of adequate training can predispose the workers to accidents, injuries, and exposure to pollutants (Yu et al., 2016; Yang et al., 2019; Burns et al., 2019). The findings show that about 81% of the respondents work full shifts of 8 hours or more daily. The crude nature of the job and the inherent inadequacies of informal e-waste recycling processing could have led to extended work periods (Zolkoniv et al., 2021). Despite such extended hours, earnings appear to be low, with a significant 42.5% earning below 3000 Naira daily, and the income is not consistent. The national minimum wage remains between 18,000 (USD24) and 30,000 (USD40) Naira per month as some states are

yet to comply when this research was conducted (Odejimi and Ugiagbe, 2019) which does not adequately cover the living expenses of many, subsequently affecting their quality of life. This finding is related to an earlier result by Burns et al. (2019), that the correlation between the time e-waste recyclers spent at work and the pay they get was insignificant and regarded as poor. Additionally, the smoking habits of participants present another aspect to be highlighted. The 33.9% reporting as smokers, combined with the 30.6% who had previously smoked but quit, may infer potential health risks, specifically when heightened with exposure to e-waste pollutants.

5.2 Awareness and knowledge of the impact of safety practices in the workplace among scavengers.

A crucial aspect of this study revolved around gauging the recyclers understanding of the health risks linked to informal e-waste recycling activities, the preventive measures in existence and the overarching implication this bears on human health. According to Trevethan (2017), it is necessary to delineate what knowledge and awareness represent when used in different domains in studies. In this study, knowledge and awareness are evaluated distinctly, providing a context to each of the domains for empirical precision. Knowledge refers to having the understanding and information that is backed with objective facts, details and accuracy. It could be acquired through training, education and being able to apply them. However, awareness refers to having a perception and familiarity with certain details and involves a basic level of understanding or simply the acknowledgement of the existence of certain facts, without a deep understanding or knowledge about the facts (Trevethan, 2017).

Data obtained indicated a moderate level of awareness and knowledge among respondents. The findings suggest that participants possess a moderate level of understanding of the health hazards associated with e-waste and maintain a marginal or limited viewpoint towards practising occupational hygiene measures during work. This is in line with the findings of Yu et al. (2016), Ohajinwa et al. (2017), and Adam et al. (2021), who found a similar level of awareness among informal e-waste workers.

5.2.3 Knowledge and awareness of health effects and hazards of e-waste

The findings of the study point out the significance of raising the level of knowledge and implementing sustainable practices in informal e-waste recycling. A significant majority, 74% of respondents, believe that sustainable e-waste management practices can potentially improve workplace safety. However, in Nigeria, while there is the existence of waste management departments in each state, the focus is on the collection of municipal waste (Mmereki et al., 2015; LAWMA, 2021). This approach leaves the handling and collection of e-waste mostly in the hands of scavengers who in turn process and recycle the e-waste in unsustainable manners (Ogungbuyi et al., 2012; Ohajinwa et al., 2017; ILO, 2019). Despite the establishment of two notable recycling facilities in Nigeria to foster sustainable recycling, there still exists a significant gap in achieving this because e-waste recycling is dominated by the informal sector (ITU, 2021). There is a recent amendment in the existing e-waste regulation in Nigeria which placed regulatory requirements on manufacturers, importers, recycling facilities and e-waste collection centres to register with the Extended Producer Responsibility of Nigeria (NESREA, 2022). While this is a step towards bridging the gap in the e-waste recycling issues, it is pertinent for policymakers to acknowledge the contribution of informal e-waste recyclers.

The data indicates a promising trend towards the use of protective measures where about 67% of the participants acknowledge the role of Personal Protective Equipment (PPE) in reducing exposure to e-waste hazards**.** Moreover, 58.7% acknowledged the impact of PPE in reducing health risks associated with e-waste informal recycling. However, around 32% of respondents seem to undervalue the potential benefits of using protective measures, suggesting that further education will be beneficial. Since most e-waste workers have not received a formal education, the educational approach will require taking into consideration the different learning preferences. Preferences such as informal education, workshops and seminars, and simple infographics with different languages that are common in the sites are useful means of showcasing to the workers the importance of using the appropriate PPE and correctly regularly. This finding is comparable to the results obtained by Yu et al. (2016),

Wittsiepe et al. (2017) and Awasthi et al. (2018) who observed that e-waste workers operate without any form of PPE.

Concerning risky behaviour and its impact on health, 44.2% are aware of the health hazards associated with smoking during e-waste recycling, while an equal comparison of 45% seem to lack knowledge of this risk. The risks of eating and drinking during e-waste recycling were known by only 45%, suggesting that behavioural interventions are needed among the respondents. This corroborated the assertion of Alabi et al. (2020), that most e-waste scavengers drink and eat in the contaminated areas of the informal sites. These habits further increase the risk of the uptake of heavy metals and toxins (Rautela et al., 2021).

The risks associated with the presence of heavy metals in e-waste are known by 50.5% of respondents. However, 39.4% of them potentially lack the safety knowledge and information access about the severe health effects such as respiratory diseases, cancer, and damage to the brain, kidney and liver damage associated with exposure to related heavy metals. Several studies have assessed the metal concentration in e-waste recycling sites and found significant concentrations higher in non-recycling sites (Awasthi et al., 2018; Li and Achal, 2020; Alabi et al., 2021). Similarly, only 48.2% of participants know the risks posed by toxins released during the burning of e-waste during recycling, and about 43% do not know the inherent risks (Ohanjinwa et al., 2019).

About 58% identified e-waste as a significant environmental hazard by polluting the air, land and water. On the other hand, about 37% of the respondents did not know about e-waste's negative environmental impacts, highlighting the need for increased environmental education initiatives among informal recyclers. Toxicants in e-waste can be deposited in soil, air, dust and water leading to environmental processes such as bioaccumulation and more leading to a wide spread of exposure (Li and Achal, 2020). The general understanding that e-waste has health effects was acknowledged by about 60% of the participants. However, 31% appear to have limited knowledge of the harmful effects of e-waste on human health. Due to the complicated nature of e-waste toxicants, it is required that all informal e-waste recyclers have knowledge of the adverse effects on human health and the environment as this will give a cue to adherence to safety practices.

In the aspects of e-waste safety guidance, around 53% of e-waste recyclers are aware that Electric and Electronic Equipment (EEE) appliances are accompanied by safety guidance labels

but a considerable proportion of 38% are unaware that such provisions exist. The need to have safety guidance labels with warnings about the potential dangers in the electrical electronic equipment as a guide for e-waste recyclers is important. Scruggs et al. (2016) acknowledged this claim, noting that this will safeguard recyclers. The ability to read and understand may be impacting the effective use of the guidelines provided in the safety labels. This indicator suggests a compelling need for tailored communication strategies from manufacturers and regulatory bodies. In the aspect of the knowledge of safe e-waste handling and disposal methods, 47% of respondents believe in the existence of safer disposal and handling methods that can be adopted in Nigeria. Orisakwe et al. (2019), opined that the source of pollutants around e-waste sites and dumpsites are the result of informal handling and disposal of e-waste. However, around 44% are unaware of the existence of such. The lack of proper disposal and handling techniques for e-waste contributes to the problems associated with e-waste management in Nigeria (Mmereki et al., 2015). This knowledge gap means that people are inadvertently increasing the problem. Okorhi et al. (2017) in their study reported that e-waste disposal in Nigeria should be handled differently from other municipal waste due to its potential hazards.

5.2.3.1 Awareness of the harmful effects of exposure to hazardous substances in e-waste.

Data presented in section 4.2.6 explains the awareness levels of e-waste recyclers concerning their understanding of health risks associated with e-waste handling and recycling. Regarding the level of awareness of the risks of smoking while handling e-waste, 36% of recyclers are unaware of the health risks associated with smoking while burning e-waste. This finding suggests a potential lack of information regarding the compounded risks of smoking during the informal processing of e-waste. The double hazards of toxic fumes from burning e-waste and those from smoking can significantly intensify health risks. Relatedly Annamalai (2015) opined that inhaling vapour and fumes during manual processing are widespread practice among informal recyclers thereby exposing them to avoidable exposure to harmful compounds that can have long-term chronic effects.

Recognition of the dangers of eating and drinking during e-waste processing is an important safety and health concern and about half of the respondents are aware of the dangers associated with this habit. However, 41% affirmed their lack of awareness associated with

this behavioural risk which presents a health threat, considering ingestion could be a highly possible route of exposure to the toxicants present in e-waste aside, from inhalation and dermal contact. Inadvertent contamination of water and food has been reported in many studies (Grant et al., 2013; Wu et al., 2016) this further demonstrates the need for stronger safety awareness and training among the target group to mitigate against further exposure.

About 63% of the recyclers are aware of the use of personal protective equipment (PPE) as needed to shield themselves from e-waste chemicals and heavy metal poisoning. While the number is promising, 29% of the respondents who lacked awareness or underestimated the importance PPE provides against these hazards during e-waste recycling is considered worrying. This result affirmed the need for further intervention among related stakeholders to raise awareness regarding PPE use at all times. These unprotected workers are exposed to a cocktail of toxicants leading to various adverse health effects. There exists a potential risk of contamination for workers who have previously taken protective measures during e-waste processing by those who did not use PPE due to the presence of dust and residues on their body which could easily be transferred. According to Wu et al. (2016), the potential harm of dermal exposure as a form of transfer of hazardous waste posed a considerable health risk to e-waste workers and the people around them.

5.2.4 Occupational hygiene practices in e-waste handling.

The occupational and hygiene practices of e-waste recyclers reveal their safety perceptions and their safety practices at the workplace. A substantial proportion of 84% of e-waste recyclers reported handling e-waste materials without gloves. This indicates a gap in safety practice that predisposes e-waste handlers to potential skin hazards associated with e-waste. The absence of hand protection can result in direct contact with harmful chemicals and heavy metals that can be absorbed through the skin (Wu et al. 2016; Li and Achal 2020; Alabi et al. 2020). The health consequences of dermal contact with these toxic substances are diverse and can produce both acute and chronic appearances. Ohajinwa et al. (2019) in their study found dermal contact to be a major path of exposure to e-waste heavy metals and other toxins. Dermal exposure to harmful substances produces an immediate reaction which is an acute outcome resulting in irritation, redness, and rashes on the skin (Grant et al., 2013; Li and Achal, 2020). These symptoms often serve as early warning signs of the detrimental

effects of exposure to e-waste toxicants. Prolonged exposure can lead to chronic outcomes that are severe health consequences such as skin ulcers and the potential to degenerate into cancer, depending on the properties of the toxicants (Kumar and Singh, 2014; Ohajinwa et al., 2019). Physical injuries such as cuts, bruises, pricks, burns and infection of wounds are inevitable due to the use of crude recycling tools. The risks of physical injuries are increased when Gloves and other appropriate PPE and not used during manual recycling. Injuries resulting from the use of manual tools by e-waste workers were reported by Asampong et al. (2015), Yu et al. (2016) and Zolnikov et al. (2021).

The burning of e-waste to recover valuable materials are frequent practice among e-waste recyclers. The study found that 73% of participants burn e-waste parts without utilising face or respirator masks. This is worrying, given the harmful fumes and toxins released during the burning of e-waste, which can be harmful to respiratory health and the overall well-being of the individual (Manhart et al., 2011; Grant et al., 2013; Amoabeng Nti et al., 2020). The opinion of the e-waste workers concerning foot protection is alarming, as 63.40% stated that they work without safety boots because they feel they are careful and cannot get injured, and another 46.70% work without these boots because they feel that the boots are unimportant. This exposes workers to the risk of physical injury from sharp objects, trips, slips and harmful chemicals that might leak (Burns et al., 2019). Asampong et al., (2015) in their study reported that some e-waste workers apply substances such as lubricants and washing detergents for the protection of their wounds to prevent infections. Extraction of valuable materials using acid bathing is a predominantly manual process in informal recycling processes (Yang et al., 2017; Rautela et al., 2021). Over half of the recyclers (57%) reported that they do not wear eye goggles because they feel they are unnecessary. This lack of eye protection puts them at risk of ocular injuries and exposure to hazardous e-waste particles. Fischer et al. (2020), in their study, found that e-waste recyclers suffer from occupational injuries which also include eye irritation.

Almost half of the participants (48%) held the view that wearing overalls was unimportant. In an earlier study by Ohajinwa et al. (2019) in Nigeria, e-waste workers reported that wearing coveralls makes them uncomfortable due to the weather. Similarly in India, Dutta et al. (2021), reported that many e-waste recyclers indicated that they do not wear protective clothing during work. The results show a split in recyclers clothing hygiene habits indicating

that 55.60% have more than one set of working clothes. Furthermore, 56.50% wash their contaminated clothes separately after working, which is essential for preventing the spread of harmful residues to other environments. This observation corresponds with the report by Priyashatha et al. (2022), that the practice of personal hygiene among e-waste recyclers is limited.

5.2.5 Influence of safety training types on scavengers knowledge of e-waste hazards on human health.

The test results in section 4.3 revealed that regardless of the type of safety training e-waste recyclers had, their awareness levels about the detrimental effects of e-waste hazards on human health did not differ. Thus, the hypothesis that safety training types received will significantly influence the knowledge level among scavengers was not supported. The type and quality of training received may not have impacted their knowledge and facts of e-waste hazards on human health. The result shows that most of the participants learnt on the job and another substantial proportion did not receive any form of training. Burns et al. (2019) and Zolnikov et al. (2021) concluded in their study that workers in the informal e-waste recycling sector have limited access to formal training opportunities. Furthermore, the study by Ricci et al. (2016), asserted that safety training should be tailored such that it impacts workers knowledge, attitude and behaviour. The authors further explained that factors such as characteristics of the workers, settings and mode of delivery should be considered to achieve the desired outcome.

5.2.6 Education attainment influence on level of knowledge and awareness of e-waste.

Results indicated that no statistically significant differences exist between distinct levels of educational attainment and the level of knowledge about e-waste hazards among the participants. The findings pointed out that educational attainment does not significantly influence knowledge levels about e-waste hazards among informal e-waste recyclers. The result is unexpected; however, this insinuates that knowledge about e-waste hazards among the participants may be mediated by other factors, which could include but are not limited to, work experience and access to factual detailed information. The data suggests that there is a need to further assess the commonly held belief that educational attainment serves as a primary medium for greater knowledge. This outcome may be due to the fact that 28% of

respondents had no formal education and close to 51% had only primary education, suggesting that this may have impacted their ability to read, write and comprehend complex facts related to e-waste recycling. Furthermore, knowledge could have been gained if e-waste recyclers engaged in expert-designed pieces of training that are tailored to suit their various circumstances.

The second phase of the investigation is whether educational attainment influenced the level of awareness regarding e-waste hazards among e-waste recyclers. Results show that participants with secondary education exhibited significantly higher awareness levels compared to those with no formal education and those with primary education. Interestingly, no statistically significant differences were found between other pairs of educational levels. These findings suggest a varied relationship between educational attainment and awareness levels regarding e-waste hazards among recyclers. While it is tempting to assume that higher educational attainment entirely results in a higher level of awareness, the data only supports this trend for the secondary education category when compared to no formal and primary education. It is also noteworthy that the presence of significant differences primarily between secondary education and both primary and non-formal education categories calls for further investigation. Earlier studies have confirmed that the demographic trend in the informal e-waste sector has more people with low educational attainment (Yu et al., 2016; Burns et al., 2019; Popoola et al., 2019; Isaah et al., 2021). On this note, it is expected to have fewer people with tertiary education as in the case of this study findings where only 3.6% have tertiary education. Such a limited proportion can introduce challenges when making statistical conclusions about the subgroup (Akobeng, 2016). Whereas participants with secondary education showed significantly higher awareness levels compared to other groups with no formal, primary, or tertiary education, the lack of statistical difference in other pairs, especially those with higher education, might be influenced by the few respondents in the group. The limited number of participants in this category might not offer the statistical power required to identify a significant difference, even if one exists in the population of the study (Lieberman and Cunningham, 2009).

5.3 Study two: The measure of existing control methods (safety climate), safety awareness, assessment of training acquired and safety behaviour in the workplace.

5.3.1 Perceptions of safety climate in the workplace.

This study showed that the existing safety routine indicated a moderate perception and views on the presence of safety routines at the recycling sites. Informal e-waste recyclers are engaged in risky recycling processes which undermine their safety. The Nigeria country profile on Occupational Safety and Health (2016), acknowledges that the growing informal sector is attracting young and inexperienced workforce who have limited knowledge of occupational safety. While the perception of the e-waste recyclers appears to be that they engaged in preventing accidents, this is not reflected in their safety practices as seen in the result of this study. The findings in this study corroborated the report by Igharo et al. (2016), where they reported that near-zero safety practices were common among informal e-waste recyclers in Nigeria.

The results obtained suggest a moderate perception of the capacity and certainty of the recyclers to handle safety-related challenges. Given the nature of the hazards contained in e-waste which are more evident during informal recycling. It is pertinent for e-waste recyclers to have good knowledge and high competencies to handle any safety challenges during recycling activities. Commitment to workplace tidiness has a high tendency to reduce workplace hazards. The findings in the study denote a collective responsibility to maintain tidiness**.** The result obtained for the item that seeks participants' collaborative effort towards Safety **(**M= 3.32, Mdn = 4.00) suggests a perceived culture where collaborative efforts towards safety are both recognised and valued. This baseline perception of the informal e-waste recyclers is fundamental and provides more insight into approaches that can be employed in creating safe workplace practices. Christian et al. (2009) and Neal and Griffin, (2006) asserted that individual safety perception has a great influence on the overall safety climate in the work environment. Safety perception during collaborative tasks is reflected in the results showing the significance of group dynamics in ensuring a sense of safety. The general safety climate in a work environment is fundamental in enhancing collective safety-related behaviours, attitudes and practices (Deng et al., 2020).

5.3.2 Factors influencing safety climate among e-waste recyclers.

This study showed that safety awareness has a significant positive impact on the safety climate. The findings suggest that increased safety awareness positively correlates with a better safety climate. E-waste recycling activities are mostly conducted in the informal sector in Nigeria, which is characterised by a lack of infrastructure and recycling activities are carried out in crude manners as reported by Perkins et al. (2014), Nnorom and Odeyingbo (2019) and Okeme and Arrandale (2019). In addition, the result revealed that safety behaviour has a significant negative impact on safety climate, implying that the safety behaviour and control methods in this sector are limited. This finding is an indication that some adverse safety behaviours could weaken the perceived safety climate within the informal recycling site. The study presents empirical evidence that safety awareness and safety behaviour are principal factors influencing the safety climate in informal e-waste recycling settings.

While safety awareness enhances the safety climate in the workplace, an interesting finding is the negative impact of safety behaviour on the safety climate. This finding suggests that certain behaviours, yet classified as 'safety behaviours,' do not align well with workers' perceptions of a secure and protective work environment. This suggests that a range of activities and procedures are probably not viewed as enhancing workplace safety among e-waste recyclers. This claim can be corroborated by the findings of Grant et al. (2013) and Daum et al. (2017) where a range of behaviours such as non-usage of PPE and disregard for relevant occupational safety procedures are prevalent among e-waste recyclers. Furthermore, Neal and Griffin (2002) analysed that individual subjective levels of knowledge and awareness of safety hazards, risks and safety behaviour in the workplace all provide a positive outcome that affects the safety climate in the work environment.

5.3.3 Relationship between collective efforts in the workplace and positive safety behaviour among e-waste recyclers.

"Collective Efforts at the Workplace" (WT) was perceived as a significant predictor for both "Working Together to Ensure a High Level of Safety" (HS) and "Feeling Safe When Working Together" (FS). The mediation analysis indicates that FS serves as a partial mediator in the relationship between WT and HS. This finding highlights the role of collective efforts and feeling safe in promoting safety climate among e-waste recyclers. This discovery strongly

indicated that promoting a sense of safety during collaborative tasks can increase the positive impacts of collective workplace efforts on the safety climate.

Social Identity Theory (SIT) posits that individuals obtain aspects of their identity and self-perception from the groups to which they belong (Taijfel and Turner, 1986). Therefore, individuals tend to act in ways that conform to the norms and values of their group even in the workplace (Choi and Lee, 2022). This study's findings support the social identity theory providing the understanding of how "Collective Efforts at the Workplace" (WT), "Working Together to Ensure a High Level of Safety" (HS), and "Feeling Safe When Working Together" (FS) are related to influencing safety climate in the informal recycling setting. This finding is supported by the assertion by Sabbir et al. (2023), that collective cultures can influence positive behaviour and attitudes toward sustainable practices for e-waste recycling. Andersen et al. (2018) and Choi and Lee (2022) in their study equally suggested that a collective sense of belonging and shared identity regarding safety makes individuals predisposed to engage in safety behaviours that translate into positive safety impact in the workplace.

5.4 Study three: Quality of work life among e-waste recyclers.

5.4.1 What factors can improve the quality of work life among informal e-waste recyclers?

The concept of quality of work life is not just about contentment with a job and productivity as earlier perceived by some authors (Martel and Dupuois, 2006). The concept has evolved, while it refers to factors related to work and its environment, it includes other dynamics that influence the individual general well-being. E-waste recycling in Nigeria is dominated by the informal sector and there is evidence that the informal workforce lacks the influence and advantages that those in formal work settings have. This typically deprives them of annual paid leave, social security coverage, sick leave and other well-being support (ILO, 2017).

5.4.2 Patterns and relationships within the Quality of work-life construct.

Factor analysis serves as a robust technique for understanding the underlying structure and dimensions of a set of observed variables in the quality of work-life construct employed in this study. The findings provided insights into the underlying patterns and relationship among the variables in the construct and identified the factors influencing the quality of work life among informal recyclers. Five factors were identified that collectively accounted for 53.037% of the variance. This is a significant proportion and gives weight to the identified factors as constructs in understanding the concept of quality of work life among the respondents. The factors obtained through factor analysis were job Satisfaction, general well-being, occupational stress, work environment, and home-work balance as shown in Figure 5.1. Informal e-waste recyclers are saddled with uniquely challenging conditions which include exposure to hazardous substances, injuries, unfavourable work environment, job stress, access to training and low irregular income (Burns et al., 2016; Burns et al., 2019; Ricci et al., 2016; Zolnikov et al., 2021). These challenges make them vulnerable to occupational health and safety risks that impact their state of health and well-being. However, Sirgy et al. (2001), Identified seven factors of QoWL and further classified them as lower and higher-order needs. They reported that workplace practices that impact job satisfaction and other general well-being are related to Maslow's need satisfaction model. The different levels of needs identified by Maslow can create a work environment where workers experience job satisfaction and also reach a phase where they can accomplish their set goals and achievements, thus attaining a high quality of work life (Sirgy et al., 2001). Figure (5.1) below is an illustration of the emerged factors in the quality of life construct from the result presented in Table 4.13.

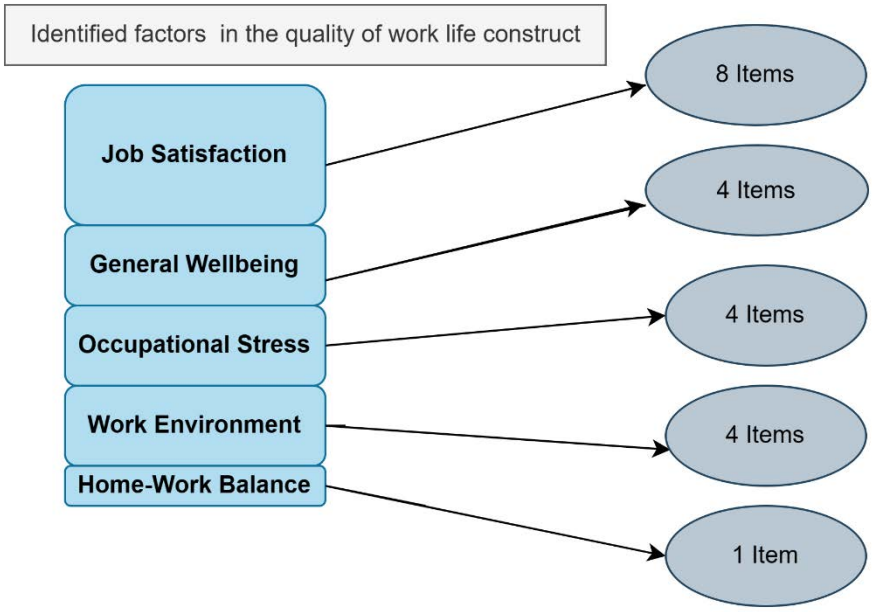

Figure 5.1: Factors influencing quality of work-life.

5.4.3 Factors affecting quality of work-life.

Following the delineation of the five domains of the Quality of Work Life (QWL) within this study, it becomes necessary to ascertain the extent these factors influence the overall QWL of informal e-waste recyclers. Additionally, the contribution of each factor to the overarching QWL construct deserves further examination. This analysis revealed the significance of each factor and provided an understanding of the dimensions of these factors. Thus, supporting earlier studies that the quality of work life is influenced by multiple variables (Swamy et al., 2015; Steffgen et al., 2020).

In comparing the level of the predictors influence on the dependent variable, Job Satisfaction (JS) emerges as the most impactful predictor, indicating its prevalence in the QWL among e-waste recyclers**.** In support of this finding, ILO (2019), identified feelings of low job satisfaction as a threat to those working in the informal e-waste recycling sector due to the lack of access to training, skills development and limited opportunities to secure higher-paying jobs. Other predictors are general well-being, occupational stress, work environment, and finally home-work balance respectively. All predictor variables were found to have statistically significant coefficients ($p < 0.001$), confirming that each of them separately contributes to explaining the

factors that influence the quality of work life among e-waste recyclers. The results suggest that a positive work environment is associated with increased Job-satisfaction, job security, a safe work environment, reduced occupational stress, home-work balance and general well-being.

5.4.4 Job Satisfaction as the dominant factor and its interplay with other factors in the quality of work-life.

Job satisfaction is an important component in understanding the broader framework of Quality of Work-Life (QWL) and notably contributes to the overall QWL. However, job satisfaction may be subjective but satisfied workers mostly perceive their work life in a positive dimension. In their study, Dhamija et al. (2019) found that Job satisfaction indexes explained about 60% variance in the quality of work-life construct that was applied in their study. This again supports the importance of job satisfaction among the components of quality of work life. In the study of informal e-waste recyclers in Nigeria by Manhart et al. (2011), most of the workers reported a low level of job satisfaction, indicating a prevalent feeling of dissatisfaction among the workers. Although job satisfaction emerged as the dominant factor, the findings suggest that if other factors such as general well-being, occupational stress, and work environment are in desirable states there will be an increase in job satisfaction.

5.4.5 Influence of income levels on quality of work life among participants.

The potential influence of income levels on the quality of work life (QWL) among informal e-waste recyclers was examined. Data revealed significant differences between the medium and higher (> NGN6000) income groups as well as between the lower and higher income groups**.** This result confirms that income levels significantly impact the QWL among informal e-waste recyclers. This finding aligns with existing research that has correlated income to QWL in various occupational sectors. In a previously reported finding by Monteith and Giesbert (2017), informal workers perceive good work as one that yields good income and is a major motivation for many people in informal employment.

5.5 Conceptual implications.

Drawing on two key theories, Social Identity Theory and Health Belief Model with other variables, the framework played a key role in shaping the study's direction and interpretative lens. This section will provide a detailed exploration of the conceptual framework, highlighting its significance in this study.

Health Belief Model (HBM): The Health Belief Model (Rosenstock, 1974), facilitated an in-depth understanding of the individual perceptions and behaviours surrounding the health risks associated with e-waste recycling. The model is grounded in the individual's perceptions of the susceptibility to and severity of a health problem significantly guiding the first two research questions. The model posits that an individual's readiness to act for the improvement of their health is a function of the perceived severity of potential health issues and the perceived benefits of taking preventative actions (Jones et al., 2015).

Perceived susceptibility and severity: The findings in this study show that e-waste recyclers demonstrate a significant gap in their understanding of the potential hazards associated with e-waste. This deficiency in knowledge and awareness influences their perceived susceptibility to and severity of potential adverse health and environmental outcomes related to e-waste. Lindsay and Strathman (1997), stated that individuals will take health-related actions if they perceive threats and negative consequences. The creation of knowledge and awareness will initiate actions that will improve health and wellbeing (Carpenter, 2019). Without an understanding of the threats posed by the rudimentary recycling of e-waste, recyclers will continue to underestimate their vulnerability to the potential adverse effects on their health and the environment.

Perceived benefits and barriers: The limited understanding of the importance of Personal Protective Equipment (PPE) highlights a lack of awareness about the benefits of such protective measures. The benefits of adopting occupational hygiene practices were not clearly recognised by the recyclers. The findings also explain limited safety behaviour and awareness among e-waste recyclers. Earlier studies have indicated that individuals will take health-related actions if they perceive the actual benefits of those actions outweigh the barriers (Rosenstock, 1974; Asampong et al., 2015). Concurrently, economic constraints, reflected in their lack of adequate income, and the unstable work conditions might serve as substantial perceived barriers, further deterring them from adopting protective behaviours.

Implications for well-being: The HBM highlights the interrelation of health beliefs and behaviours (Asampong et al., 2015). The current state of knowledge, awareness, and safety practices among the surveyed e-waste recyclers adversely impacts their overall well-being (Yu et al., 2016). Their reduced health and safety practices, driven by their beliefs and perceptions, put them at heightened risk for detrimental health outcomes, which further impairs their quality of work life.

Knowledge and awareness: Reflecting on the theory of the Health Belief Model (Rosenstock, 1974), there exists a lack of knowledge and awareness of the extensive health and environmental effects among informal recyclers that prevent the adoption of the use of PPE and safer handling of e-waste. This is strongly supported by hypotheses H1 and H2. The findings in this study underline the potential of education to strengthen knowledge and awareness regarding the potential hazards of e-waste. Thus, presenting a compelling argument for the integration of tailored educational and training interventions that include the informal sector in policies governing e-waste management in Nigeria.

Social Identity Theory (SIT): Through the lens of SIT, it was observed that group dynamics and shared identities significantly influence safety behaviour and safety climate. It was discovered that the shared identities could potentially foster collaboration aimed at establishing safer work environments, a concept that was examined under hypothesis H4.

Group identity and safety behaviour: The potential influence of group dynamics in shaping safety behaviours among e-waste recyclers was evident in this study. According to SIT, individuals are likely to adapt to the norms and behaviours of their group, seeking positive uniqueness and group identification (Taijfel and Turner, 1986). The present study shows that if a collective emphasis on safety becomes a fundamental part of the e-waste recyclers' group identity, it could drive individual members to adhere more stringently to safety protocols, thus supporting a safer work environment.

Shared norms and enhanced safety climate: The findings suggest that shared norms and values can potentially improve the workplace safety climate. A robust safety climate strengthened by shared beliefs and mutual understanding is crucial in mitigating risks and hazards (Choi and Lee, 2022). This finding supports the conclusion that collective efforts can yield a practical and consistent adherence to occupational safety practices (Haslam et al., 2009; Saphore et al., 2012)

Influence of on-the-job training: The study reveals the prevalent lack of formal training among e-waste recyclers. Many acquired skills on the job, while some have no training at all however, on-the-job training can be ambiguous. While it reinforces the group identity through shared experiences and practices, it might also perpetuate unsafe work procedures if they have become rooted as group norms (Haslam et al., 2009).

Safety climate and quality of work life: The findings introduce additional perspectives in the discourse on occupational safety and health in the informal sector such as e-waste recycling. In this study, there is an emphasis on the efficacy of collective efforts rooted in shared identities under the lens of SIT and the acknowledgement of health benefits which is a core principle of HBM (Webber et al., 2022). The significance of job satisfaction, general well-being, occupational stress, work environment and homework balance as factors influencing the quality of work life among e-waste recyclers were evident in the study.

This research provides essential conceptual implications arising from the application of the SIT and HBM in analysing the dynamics of informal e-waste recyclers and their workplace practices. This study not only delineates the relationship between group dynamics and safety climate explored through the lens of SIT but also reveals the critical role of individual health beliefs and behaviours in shaping their responses to e-waste hazards to human health and the environment, as guided by HBM.

5.6 Critical observation of findings

The study unveiled a moderate level of awareness and knowledge about e-waste hazards among the surveyed e-waste recyclers. It is commendable that there is an existing foundation to build upon; however, the limited application of this knowledge in daily practices is concerning given the hazardous chemicals and toxins found in e-waste. The lack of a significant relationship between education level and awareness hints at the prevalence of individuals with limited education working in the e-waste informal sector**.** Furthermore, the positive correlation between safety awareness and safety climate suggests that improvements in safety awareness could foster better safety climates. Yet, it was noted that the prevailing safety procedures were only moderately perceived, indicating a gap between awareness and actual practices in the workplace.

A notable aspect worth discussing is the interplay between the HMB and SIT models in shaping health and safety behaviour among informal e-waste recyclers. The HBM appears as particularly influential in the study results, positioning itself as a foundational element. The HBM significance lies in its capability to establish a baseline for acquiring appropriate health and safety behaviours. This model explores individual perceptions, encompassing factors such as perceived susceptibility to risks, the severity of potential consequences, perceived benefits of adopting safety measures, and perceived barriers to such adoption. By addressing these aspects, the HBM provides support for understanding and fostering health and safety behaviour. It establishes the foundation for tailored interventions that target individual beliefs and motivations, laying the groundwork for the adoption of recommended health and safety practices in the workplace.

Furthermore, the SIT is recognised for its potential contribution to the overall framework. In comparison, while the HBM focuses on individual perceptions, the SIT brings a collective dimension into play. The study results suggest that the SIT becomes particularly relevant in building on good practices acquired at the individual level for group compliance. As informal work sectors often involve cohesive communities in the form of local unions, and trade associations with common interests as observed among the informal e-waste recyclers. Hence, SIT can be leveraged to understand and influence the group dynamics that shape behaviour. Group identity and social norms within these informal settings can significantly impact the adoption of health and safety practices. Consequently, the SIT becomes an essential component in extending the positive outcomes learned at an individual level to the broader group context, promoting a culture of collective compliance and shared responsibility for safety measures. This integration offers a robust framework for promoting health and safety behaviour within the context of informal work sectors, contributing to the advancement of practical and effective interventions.

5.7 Limitations and strengths of the study.

The level of literacy among the participants was a challenge as some participants could not communicate in simple English. To mitigate this, the field assistant team consisted of individuals who are multilingual and communicate in Yoruba, Hausa, and Pidgeon English. At the initial stage, reluctance to participate in the research was detected. To overcome this challenge frequent visits were made to the sites to build rapport and interactions to ensure they were comfortable to voluntarily consent to participate in the research. Reaching out to more potential participants was not possible due to budget constraints. The increase in the cost of printing and transportation was an additional limitation to reaching out to more participants. The potential for over-generalisation of the outcomes due to sample selection was identified. Given that a non-probability sampling method was utilised, the sample may not comprehensively represent the broader population. Hence, the sample population was carefully selected based on relevant characteristics required for the study to mitigate over-generalisation. Lagos state is the heart of commerce in Nigeria and has the country's highest activity of e-waste recycling. Alaba International Market and Ikeja Computer Village were selected because they are the major recycling sites in the State. It was ensured that the sample size was adequate to allow a good representation of the population.

A survey design was appropriate due to the large sample, the scope, and the use of multiple questionnaires to collect data to bring different perspectives and in-depth understanding to the study. While a few of the survey questions barely reached the reliability thresholds, the informal nature of the workplace and the population of study made it difficult to adopt a general standardised instrument.

The strength of this study is evident, based on the available information in the database, it represents the first assessment of the quality of work life among informal e-waste recyclers in Nigeria. The study provides further insights into how to improve the safety and health practices among e-waste recyclers. In addition, this research offers valuable insights into informal e-waste recycling activities and identifies prevailing gaps in existing policies and regulations.

6.0 CHAPTER SIX: CONCLUSIONS AND IMPLICATIONS

This study assessed the health and safety impact of e-waste handling among informal recyclers, collectively referred to as scavengers, in Nigeria. This study aims to assess health and safety awareness levels and evaluate the quality of work life among informal e-waste recyclers to enhance their occupational health, safety practices and well-being. The aspects of this research can be viewed from 3 broad scopes. The broad aspects are (i) assessment of knowledge, awareness and practices related to e-waste recycling activities among informal recyclers (ii) assessment of existing control methods, safety awareness training and safety behaviours of e-waste recyclers in the management of exposure to e-waste hazards, and (iii) the measure of the quality of work life among e-waste recyclers. The essence of this approach is to facilitate a comprehensive understanding of the research problem, explore existing knowledge identify gaps and provide an approach to understanding multidimensional challenges such as those faced by informal e-waste recyclers in Nigeria.

Many scavengers demonstrated a moderate level of awareness and knowledge regarding the health impacts of e-waste. However, this understanding did not necessarily translate into adequate occupational hygiene practices, with most participants displaying limited adherence to health and safety procedures at the workplace. This leads to exposure to toxic substances and poses significant health risks. This finding points out the necessity to increase awareness and foster better hygiene practices to promote a safer work environment. This will support the achievement of the SDG 3 and 8 objectives. SDG 3 prioritises the reduction of deaths and illnesses from hazardous chemicals, air pollution, and water and soil contamination. SDG 8 targets include the promotion of a safe and secure working environment for all workers (UNSDG, 2015).

Surprisingly, educational attainment did not significantly influence the scavengers' knowledge levels. The findings show that most e-waste workers had little or no education which could have impacted their knowledge of e-waste risks and hazards. The findings seem to suggest that other factors, such as work experience and access to accurate information and training,

might play more crucial roles. Thus, interventions beyond formal education are necessary to increase awareness levels.

A positive correlation was found between safety awareness and safety climate, highlighting the essential role of safety awareness in promoting a safety climate in the workplace. The importance of collective efforts in promoting positive safety behaviour was established with a clear correlation between collaborative activities in the workplace and enhanced safety behaviours among e-waste recyclers. Observations from the data pointed out that the shared norms and identity of workers promote a culture of shared responsibility towards safety protocols, thereby reducing the likelihood of accidents and creating a safer work environment. Hence, encouraging teamwork can be seen as a crucial step in promoting safe conduct in the workplace. This finding can be linked to the objective of understanding and improving safety climate per SDG 8 targets.

Job satisfaction emerged as a dominant factor affecting the quality of working life, which interrelates with general well-being, occupational stress, work environment, and home-work balance. Also, higher income levels were found to positively influence the quality of working life, noting that adequate income plays a vital role in improving the well-being of workers. This is an indicator that an increase in income allowed workers to access better safety equipment and adhere to improved safety standards, hence enhancing their quality of work-life. The findings suggest the need for strategies that enhance job satisfaction and economic stability in the informal sector as required by SDG 8.

6.1 Implications

Moving forward, it becomes imperative to design interventions that not only increase awareness but also translate knowledge into daily practice, addressing the existing gaps in occupational hygiene measures. Educating informal e-waste scavengers, especially those with little to no formal education, can present challenges. Their reluctance can be because of distrust, fear of losing their livelihood, or the opinion that such education may not be beneficial. Community outreach and capacity building involving all stakeholders, including policymakers, should be considered to promote a better understanding of e-waste management and its impacts on health and safety. Adopting an informal approach with the use of learning materials that are relatable to the lived experience of the e-waste workers will

be impactful. Strategies such as case studies, peer educators, use of posters and pamphlets that will be written in pidgin English, Yoruba, Hausa and Ibo.

Moreover, considering the disconnect between education level and knowledge about e-waste hazards, future research should explore alternative options through which a level of awareness can be increased. Exploring this relationship with a larger sample of those with higher education may be relevant to decisively determine this association.

6.1.2 Contribution to knowledge

This study has brought to light nuanced findings around the understanding and practices of e-waste scavengers in Nigeria, It has provided new evidence so that sustainable e-waste management plans can be designed, thus playing a vital role in advancing efforts toward SDGs 3, 8, and 11. This research contributed to the current body of knowledge by investigating the existing safety climate at informal e-waste recycling locations, an area not extensively covered in the existing literature. The uniqueness of this study also lies in the examination of -safety behaviour and awareness of informal recyclers under the lens of Social Identity Theory. Moreover, the study challenges the conventional belief that education always correlates with increased awareness, highlighting the role of other mediating factors in knowledge acquisition, which is a significant contribution to the existing literature and a crucial insight for policy formulation.

6.1.2.1 Inform policy realignment.

Despite the presence of international, regional, and national regulations on e-waste in LMICs such as Nigeria, the current lax enforcement poses a significant challenge. To effectively address the negative impacts of e-waste, it is imperative to advocate for a thorough policy realignment. This research has the potential to serve as a reference for policy realignment in the development and implementation of laws that protect informal e-waste recyclers and the community at large, driving towards achieving Sustainable Development Goals. A reassessment and adjustment of existing policies related to e-waste management to include informal sectors is needed. The goal is to enhance the effectiveness of policies in achieving the intended outcomes in addressing the challenges associated with e-waste management by including all involved. The formulation and implementation of tailored health and safety guidelines can build a secure workplace for e-waste workers, fostering positive health and safety practices that contribute to their overall well-being.

The recommendations arising from this study are envisaged to serve as a crucial resource for policymakers and stakeholders. Encouraging them to reevaluate and reinforce policies for sustainable e-waste management, thereby mitigating environmental and health risks associated with rudimentary e-waste recycling activities.

Based on the findings, the following recommendations are proposed:

Development of tailored interventions: The e-waste sector in Nigeria is dominated by informal recyclers and no doubt that their activities contribute to the economy despite the crude processing methods. The Agency responsible for e-waste management in Nigeria should provide an inclusive platform for informal e-waste recyclers. The first step towards a safe and sustainable e-waste management strategy is the formulation of interventions that resonate with the ground realities of scavengers. The design of interventions that are tailored to the existing knowledge levels and daily experiences of the informal e-waste recyclers, with a focus on practical applications to enhance safety and hygiene practices. Informal learning materials such as multilingual infographics, and practical demonstration of the proper use of PPE, safe handling, segregating and processing of e-waste should be offered to recyclers. Simple checklists to remind them of safe practices when handling e-waste could be in the form of a laminated card and with visuals.

Safety protocols: Develop safety protocols that are easy to understand and implement, focusing on the daily experiences of the scavengers.

Hygiene workshops: Regular workshops and on-ground training sessions can be initiated by National Environmental Standards and Regulations Enforcement Agency (NESREA) in conjunction with producer-responsible organisations such as E-waste Producer Responsibility Organisation Nigeria (EPRON) to cultivate hygiene practices considering the specific needs and working conditions of the scavengers.

Community engagement: Foster community engagement and participatory approaches to improve awareness and knowledge at the grassroots level. E-waste hazards are not limited to the e-waste recyclers, the people who live and work around the e-waste recycling sites are also at risk. Public Awareness that will focus on the adverse effects of improper e-waste management will raise awareness and enhance positive behaviour.

Circular economy approach: Incorporating the principles of a circular economy in e-waste management means promoting product designs that are more durable, easily repairable, and recyclable, encouraging the utilisation of recycled materials in manufacturing new products. Encouraging an environment that facilitates the reuse of electronic devices through refurbishment and reuse is pivotal. This approach goes hand in hand with raising awareness among consumers and producers alike, promoting knowledge about the potential hazards of improper e-waste disposal. On this note, adopting the waste management hierarchy framework will support the circular economy approach. This approach will equally help in preserving the loss of valuable materials that are prevalent in informal recycling. To effectively transition to a circular economy approach for e-waste management, collaborative efforts are required, involving government bodies, manufacturers, and the community at large.

Extended producer responsibility: In surveying potential strategies to improve e-waste management, the concept of extended producer responsibility (EPR) emerges as a workable recommendation. EPR is a strategy that mandates producers to be responsible for the environmental impacts of their products throughout the products' life cycles, including end-of-life management. EPR exists in Nigeria but the strategies are only partially implemented.

Implementing an EPR strategy means that manufacturers are not only responsible for creating products but also for their recovery and recycling once they reach the end of their useful life. Consequently, this policy encourages producers to design products that are easier to recycle, reuse, and refurbish.

Sustainable Development Goals: Aligning the policies with the Sustainable Development Goals (SDGs), particularly focusing on SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 11 (Sustainable Cities and Communities).

Capacity building: Encourage capacity-building initiatives aimed at improving workplace safety, health, and well-being among scavengers, including the development of educational materials that consider the educational background of the target audience. Strengthening the potential and abilities of e-waste recyclers can potentially lead to a better workplace environment. Given that most of the e-waste is recycled in the informal sector in Nigeria.

Educational and training material: Develop educational materials considering the literacy levels and comprehension abilities of the scavengers, focusing on visual aids and simple

language, local languages, and infographics to convey the necessary information effectively. In addition to formal training programs, informal learning and peer-to-peer knowledge sharing will play a significant role in shaping safety behaviour among informal workers in Nigeria. Informal workers often rely on the experiences and practices of their peers within their social networks to learn about safety measures and precautions.

Skill development: Introduce skill development programs to enhance the recyclers skill set, ensuring better job opportunities and career growth, this will have a positive influence on their quality of work life.

Promotion of collaborative efforts: Encourage collective efforts in the workplace to foster a positive safety culture and safety climate. Leveraging the existing moderate perception of safety practices and behaviour to build a safer work environment. Positive health and safety behaviours acquired from training and other educational interventions can be fostered in the broader group context by collectively promoting a culture of collective compliance and shared responsibility for health and safety measures in the workplace.

A synergy of extended producer responsibility, circular economy approach, and policy realignment in e-waste management in LMICs

Low and Middle-Income Countries (LMICs) are faced with the dual challenge of managing e-waste generated in their country and the inflow from high-income countries. Most of the recycling is done in the informal sector as already acknowledged in the study. An integrated approach involving Extended Producer Responsibility (EPR), the Circular Economy, and policy realignment presents a rounded sound solution for e-waste management in LMICs with the inclusion of the informal recycling sector.

EPR organise the collection process and involves informal recyclers through certified channels, ensuring they benefit from standardised practices without losing their livelihood opportunities. The certified channels will give the opportunity to pieces of training and workshops that will facilitate in development of safety practices, thereby reducing the health risks associated with unsafe recycling practices. The EPRON will require expertise in occupational health and safety, environmental health and safety, occupational hygienists and other related experts to deliver tailored training and workshops that suit the different learning competencies of informal e-waste recyclers. Behavioural intervention training that

will aim to modify the practices and beliefs of recyclers towards safe workplace practices. Experts will be able to deliver content that includes knowledge and awareness of hazards, safe handling practices, health monitoring and environmental best practices.

Embracing a circular economy model can reduce the volume of e-waste generated in LMICs by promoting longevity in electronics and facilitating their repair and refurbishment. Promoting sustainable recycling will improve the economic benefits of extracting valuable materials from e-waste. Many LMICs lack strong policy frameworks addressing e-waste comprehensively. Through realigning policies, there will be an enabling environment that facilitates successful EPR and the adoption of a circular economy that enhances e-waste management.

The convergence of EPR, Circular Economy, and policy realignment can offer LMICs a robust framework for e-waste management. While EPR provides a regulated system for waste collection and processing, the Circular Economy approach highlights waste reduction and resource maximisation. When supported by well-aligned policies, these strategies can thrive in coherence ensuring that e-waste is managed sustainably.

6.1.3 Suggestions for further research.

•The present study adopted a cross-sectional approach it hereby suggested that longitudinal studies should be undertaken to investigate the long-term effects of e-waste recycling on the health and well-being of the scavengers, with a focus on chronic diseases and other health conditions.

•Mixed method research should be considered as this will help gather both objective and subjective perspectives from e-waste recyclers. This will also allow the exploration of human behaviour, perceptions, motivations, emotions, and experiences.

•Interventional studies that explore the efficacy of various awareness-building and training programmes aimed at improving the safety and health outcomes for e-waste scavengers should be considered. Educational interventions that are tailored to the literacy levels and learning inclinations of the scavengers should be employed to enhance their awareness and safety practices effectively. Future research in this area must remain interdisciplinary, drawing from the fields of public health, sociology, environmental science, and more to

provide a holistic understanding of the dynamics at play in the informal e-waste recycling sector in Nigeria and other LMICs.

• Research to assess the impact of existing policies on the e-waste recycling sector, identifying gaps, and suggesting policy realignments to foster a healthier and safer work environment.

•Future studies should seek to analyse the environmental impacts of e-waste recycling, with an emphasis on sustainable practices that can mitigate adverse effects on the environment.

• The generation of e-waste has grown exponentially globally over time and its management in LMICs such as Nigeria is complicated by transboundary movement of e-waste from High-Income countries (Forti et al., 2020). Some countries in Europe such as Switzerland and the Netherlands among others have made good progress in the effective handling and management of e-waste (Liu et al., 2023), so Knowledge and techniques can be learnt from their practices. Therefore, future research should consider a cross-comparative study involving other countries with thriving informal e-waste recycling sectors to bring a global perspective to the phenomena observed in Nigeria. Likewise, it would be beneficial to evaluate and contrast the perspectives of recyclers from both formal and informal sectors concerning the e-waste recycling process.

•Investigate the role and implications of child and women labour in the e-waste recycling sector, proposing measures to protect vulnerable groups and ensure their welfare. While this study primarily investigates the experiences and working conditions of e-waste recyclers, a group predominantly comprised of men as indicated in the demographic attribute of this study. However, observations made at the recycling sites during data collection revealed that other vulnerable groups are at risk, most notably women and children involved in ancillary activities within the recycling sites such as selling goods and food. The detrimental effects of heavy metals and toxins on children and exposure during pregnancy have been evident in various studies. Exposure of pregnant women to these substances can potentially have adverse health outcomes such as low birth weight and neurodevelopmental deficit in the neonates (Grant et al., 2013; Li and Achal, 2020; Alabi et al., 2020; Rautela et al., 2021).

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APPENDICES

Appendix I: Participant Information Sheet (Survey Study)

Health and Safety Impact Assessment among e-waste scavengers in Nigeria

1. Invitation to research

You are invited to take part in my research study. My name is Stella Ebalehita Ibifunmilola, a postgraduate degree student (PhD) of the above-named institution conducting a research project on Health and Safety Impact Assessment among e-waste scavengers in Nigeria. The study seeks the perceptions of Scavengers and stakeholders in e-waste safety management to help suggest possible measures to improve safety and health practices among e-waste handlers.

2. Why have I been invited?

This study aims to assess the health and safety impact of e-waste Scavengers during the handling of e-waste materials, thus seeking your perceptions as a Scavenger or a Stakeholder in e-waste management on ways to address this problem and advance tailored recommendations. To achieve the study goal, you are invited to take part in the survey as you have been identified as a key stakeholder in Informal e-waste management. Aged 18 and above and have been working in the sector for more than one year either in the Alaba International Market and/or Ikeja Computer Village.

3. Do I have to take part?

It is up to you to decide. If you chose to take part, we will describe the study and go through the information sheet, then allow you time to make up your mind. You will be asked to sign a consent form to show you have agreed to take part. You are free to withdraw at any time, without giving a reason. However, data already collected would still be retained and used as it is considered highly anonymised/unidentifiable therefore will not be possible to identify any participant data after collection and collation.

4. What will I be asked to do?

This research will require that you complete three sets of questionnaires, and each will take about 10 minutes to complete. Data collected will be strictly anonymous.

5. Are there any risks if I participate?

There are no known potential risks involved in your participation in the study. Where you find any question sensitive, the researcher will be on hand to offer further clarification and allow you time to consider your decision while ensuring your wellbeing if given high priority.

6. Are there any advantages if I participate?

Yes, there are advantages in taking part in the survey. During the data collection, you will be able to ask questions regarding personal safety at work and you will be provided with needed responses while enhancing your safety knowledge. Your response will provide insight into the health and risks hazards involved with e-waste management. Also, the study will be able to recommend sustainable ways to promote and adopt positive environmental, health, and safety behaviours among e-waste handlers. The study's findings may help to encourage policy realignment and engage concerned stakeholders to achieve sustainable e-waste management and related United Nations Sustainable Development Goals (3, 8 &11). The outcome of the study may provide up-to-date information that can help increase business knowledge in the existing e-waste management settings.

7. What will happen to the samples that I give?

There will be no need to provide any biological samples in the course of the study**.**

8. What will happen with the data I provide?

When you agree to participate in this research, we will collect from you personally identifiable information.

The Manchester Metropolitan University ('the University') is the Data Controller in respect of this research and any personal data that you provide as a research participant will be handled confidentially.

The University is registered with the Information Commissioner's Office (ICO), and manages personal data in accordance with the General Data Protection Regulation (GDPR) and the University's Data Protection Policy.

Personal data to be collected as part of this research include name, telephone numbers or age. As a public authority acting in the public interest, we rely upon the 'public task' lawful basis. When we collect special category data (such as medical information or ethnicity) we rely upon the research and archiving purposes in the public interest lawful basis.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. We will not share your personal data collected in this form with any third parties.

If your data is shared this will be under the terms of a Research Collaboration Agreement which defines use and agrees with confidentiality and information security provisions. It is the University's policy to only publish anonymised data unless you have given your explicit written consent to be identified in the research. **The University never sells personal data to third parties.**

We will only retain your personal data for as long as is necessary to achieve the research purpose. Data cannot be traced to any individual directly or indirectly. For this research no sensitive data will be collected and any other data collected will be anonymised at the point of collection in order to preserve the participants' confidentiality.

Data will be stored on the University one drive and the researcher computer will be password secured.

For further information about use of your personal data and your data protection rights please see the University's Data Protection Pages (https://www2.mmu.ac.uk/data-protection/).

What will happen to the results of the research study?

Findings of the research will be disseminated through peer-reviewed journal publications, conferences and publication websites and the entire study will be developed into a thesis for the award of a PhD.

Who has reviewed this research project?

The project Supervisory team and Ethics Committee of Manchester Metropolitan University.

Who do I contact if I have concerns about this study or I wish to complain?

Researcher

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If you have any concerns regarding the personal data collected from you, our Data Protection Officer can be contacted using the legal@mmu.ac.uk e-mail address, by calling 0161 247 3331 or in writing to: Data Protection Officer, Legal Services, All Saints Building, Manchester Metropolitan University, Manchester, M15 6BH. You also have a right to lodge a complaint in respect of the processing of your personal data with the Information Commissioner's Office as the supervisory authority. Please see: https://ico.org.uk/global/contact-us/

THANK YOU FOR CONSIDERING PARTICIPATING IN THIS PROJECT

Appendix II : Questionnaire used in study one.

Health and Safety Impact Assessment among E-waste Scavengers in Nigeria

Health knowledge, awareness and practices related to e-waste activities.

Dear Participant,

I am inviting you to participate in this research by completing this questionnaire. This is research into health and safety impact assessment among informal e-waste workers in Nigeria. This involves collectors, dismantlers, and other workers involved in the informal recycling process. The research is based on your knowledge, awareness and practices related to e-waste recycling activities. Your contribution is voluntary and will help enhance the understanding of the research focus. Under no circumstances are you obliged to answer any of the questions. Your information will not be used to identify you at any point in this research. Thank you for your time.

Stella Ebalehita Ibifunmilola

Section A: Socio-demographic Information

Please answer the questions by ticking the appropriate option (√) or state your opinion as appropriate. Do not tick more than one option.

1. Age group: 18-23 [ ], 24-29 [ ], 30-35[ ], 36-40 [ ], 41- 45 [ ], 46 and above [ ]
2. Gender: Male [ ] Female [ ] Prefer not to say [ ]
3. Highest level of Education: No formal education [ ], Primary [ ], Secondary [ ], Tertiary [ ]
4. Number of years working as e-waste scavenger: 1-5 [ ], 6-10 [ ], 11-15 [ ], 16-20 [ ], 21 and above [ ]
5. Safety Training type Received: On-the-job training [ ], Training by an expert [ ], Never had any form of training [ ]
6. Work shift: Full day [ ], Half day [ ]
7. Income level Per Day: Ngn3000 or less [ ], Ngn3001-N6000 [ ] , More than N6000 [ ]
8. Do you smoke? Yes [ ], No (never) [ ], No (quit smoking) [ ]

Section B: Knowledge of hazardous substances in e-waste and their health effects on humans and the environment. Please tick [✓] only one opinion that applies (Strongly disagree, Disagree, Neutral, Agree, Strongly Agree)

1.

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	**1**	**2**	**3**	**4**	**5**
1	Do you know e-waste are harmful to human health?					

2	E-waste can affect the environment by polluting the air, land, and water					
3	Burning of e-waste during informal recycling releases toxins that are harmful to human health					
4	(There are many safe methods of handling and disposal of e-waste that can be adopted in Nigeria					
5	The use of personal protective equipment (PPE) i.e., gloves face masks, eye goggles, safety boots etc., can reduce the health effects associated with e-waste					
6	Safety guidance label can be found at the back of EEE appliances which indicates safe dismantling and disposal methods					
7	Heavy metals within e-waste can cause serious health problems such as respiratory disease, cancer, kidney and liver damage, chronic damage to the brain, nervous system etc.					
8	Drinking/eating while handling e-waste materials is likely to get harmful materials into our bodies					
9	Smoking cigarettes while handling e-waste can allow harmful compounds into the human body					
10	The use of personal protective equipment can help prevent exposure to harmful compounds					
11	The knowledge of sustainable e-waste handling and recycling will improve my workplace safety and health practices					

Section C: Awareness of harmful effects of exposure to hazardous substances.

We want to know your general awareness regarding the harmful effects of exposure to hazardous substances in e-waste during recycling activities. Select the response that best relates to you.

Please tick [✓] only one opinion that applies (Strongly disagree, disagree, neutral, agree, strongly agree)

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	**1**	**2**	**3**	**4**	**5**
1	Smoking while burning e-waste products is not a safe practice					
2	Drinking and eating while handling dismantling and burning materials increase harmful compound potential to gain entrance to the body					
3	Personal protective equipment (PPE) is important to prevent the body from chemical and heavy metal poisoning					

Section D: Occupational hygiene practices

Please tick [✓] only one opinion that applies

		Yes	No
1	I currently handle e-waste materials without hand gloves		
2	I regularly burn e-waste parts without the use face/respirator mask to protect myself		
3	I work without safety boots because I am careful		
4	I work without safety boots because they are not important		
5	I do not wear eye goggles because it is not important		
6	I wear overalls when I am working to protect my skin from cuts and burn		
7	I do not wear overalls because it is not important		
8	I have more than one set of working clothes		
9	I only have one set of working clothes		
10	I wash my contaminated clothes separately each day after working on the site		

General comment (please provide any further comments as you consider related to the subject)

……

……

……

Appendix III : Questionnaire use in study two.

Health and Safety Impact Assessment among E-waste Scavengers in Nigeria

The measure of existing control methods (safety climate), safety awareness, assessment of training acquired and safety behaviour in the workplace.

Dear Participant,

I am inviting you to participate in this research by completing this questionnaire. This is research into health and safety impact assessment among informal e-waste workers in Nigeria. This involves collectors, dismantlers, and other workers involved in the informal recycling process. This survey is to assess existing control methods, safety awareness and safety behaviour you adopt at your workplace as you carry out recycling activities. Your contribution is voluntary and will help enhance the understanding of the research focus. Under no circumstances are you obliged to answer any of the questions. Your information will not be used to identify you at any point in this research.
Thank you for your time.

Stella Ebalehita Ibifunmilola

Section A: Socio-demographic Information

Please answer the questions by ticking the appropriate option (√) or state your opinion as appropriate. Do not tick more than one option.

1. Age group: 18-23[ ] 24-29[ ] 30-35[ ] 36-40[ ] 41- 45[ ] 46 and above[ ]

2. Gender: Male [ ] Female [ ] Prefer not to say [ ]

3. Highest level of Education: No formal education [ ], Primary [ ], Secondary [ ] Tertiary [ ]

4. Number of years working as e-waste scavenger: 1-5 [ ], 6-10 [ ], 11-15 [ ], 16-20 [ ] 21 and above [ ]

5. Safety Training type Received: On-the-job training [ ], Training by an expert [ ] Never had any form of training [ ]

6. Work shift- Full day [ ], Half day [ ]

7. Income level Per Day: Ngn3000 or less [ ], Ngn3001-N6000 [ ] , More than N6000 [ ]

8. Do you smoke? Yes [ ], No (never), [ ] No (quit smoking) [ ]

Section B: Assessment of existing control methods, Safety awareness, training and safety behaviours adopted towards the management of exposure to hazardous substances.

Please Indicate your answers by ticking [✓] the appropriate box.

1. General Safety Climate

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	1	2	3	4	5
1	There are existing safety routines that are in practice in this work environment					
2	We do all we can to prevent accidents					
3	We who work at this site have the ability to deal with safety					
4	I have control over decisions that affect my safety at my workplace					
5	We make collective efforts to ensure that the workplace is kept tidy					
6	We work together at this workplace to achieve a high level of safety					
7	We feel safe when working together					

2. Safety Awareness

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	1	2	3	4	5
1	I always read the safety instruction label if present, before I begin the recycling process					
2	Everyone involved in e-waste recycling on this site knows the safety and risks associated with the work					
3	We meet as a group to find solutions to existing safety problems					
4	We meet as a group to identify safety concerns at the workplace					
5	I am aware that informal recycling poses a safety concern					

3. Safety Training

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	1	2	3	4	5
1	I have the knowledge of safety measures to follow in the e-waste recycling process					
2	I have received the necessary information/ training on safety					
3	I attend safety training and briefings					
4	I consider safety training to be good for preventing accidents					

4. Safety Behaviour

	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	1	2	3	4	5
1	I disregard safety rules to get jobs done on time					
2	I take risks when the work schedule is tight					
3	We consider minor accidents to be a normal part of our daily work					
4	Risk-taking during recycling is acceptable					

Please share any additional comments related to this questionnaire:

Appendix IV: Questionnaire use in study three.

Health and Safety Impact Assessment among E-waste Scavengers in Nigeria

Assessment of the factors that influence the quality of work life among e-waste recyclers.

Dear Participant,

I am inviting you to participate in this research by completing this questionnaire. This is research into health and safety impact assessment among informal e-waste workers in Nigeria. This involves collectors, dismantlers, and other workers involved in the informal recycling process. The survey is to assess those factors that influence your well-being at work. Your contribution is voluntary and will help enhance the understanding of the research focus. Under no circumstances are you obliged to answer any of the questions. Your information will not be used to identify you at any point in this research.
Thank you for your time.

Stella Ebalehita Ibifunmilola

Section A: Socio-demographic Information

Please answer the questions by ticking the appropriate option (√) or state your opinion as appropriate. Do not tick more than one option.

1. Age group: 18-23 [ ] 24-29 [ ] 30-35[ ] 36-40 [ ] 41- 45 [ ] 50 and above [ ]

2. Gender: Male [ ] Female [ ] Prefer not to say [ ]

3. Highest level of Education: No formal education [ ], Primary [ ], Secondary [ ] Tertiary [ ]

4. Number of years working as e-waste scavenger: 1-5 [ ], 6-10 [ ], 11-15 [ ], 16-20 [ ] 31 and above [ ]

5. Safety Training type Received: On-the-job training [ ], Training by an expert [ ] Never had any form of training [ ]

6. Work shift- Full day [ ], Half day [ ]

7. Income level Per Day: Ngn3000 or less [ ], Ngn3001-N6000 [ ] , More than N6000 [ ]

8. Do you smoke? Yes [ ], No (never) [ ], No (quit smoking) [ ]

Section B

This section is designed to assess your quality of work-life i.e.- your job satisfaction and dissatisfaction, working condition, stress and health as they relate to your general wellbeing.

Please indicate your answers by ticking [✓] the appropriate box.

1.

1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree	**1**	**2**	**3**	**4**	**5**
I feel well now					
I have adequate facilities and flexibilities for me to fit work in around my family life					
My current working hours/ pattern suits my circumstances					
I often feel under pressure at work					
I feel unhappy and depressed					
I am satisfied with my life					
Mostly, things work out well for me					
I work in a safe environment					
I often feel an extreme level of stress while at work					
I often take unfinished work home					
I feel safe using the toilet facilities at work					
I have access to clean and safe water at work					
I can give opinions and influence changes in my area of work					
I am satisfied with my current job					
The Working conditions are satisfactory					
I earn enough to sustain me and my family					
The nature of my job gives me concerns over my health					
I have a good working relationship with fellow workers on this site					
I receive adequate training for the work I perform					

Please share any additional comments related to this questionnaire:

Appendix V: Fisher's formula for deriving sample size

Andrew Fisher's formula:

$$n = \frac{Z2\ P\ (1 - P)}{d2}$$

Where:

n= Sample size

Z= SD for a 95% confidence level (Z=1.96)

P= Prevalence of attribute (50%)

d= Acceptable difference (if 5%, d=0.05)

q= 1-P