ANALYZING THE EFFECTS OF ELECTRONIC WASTE RECYCLING ON WORKERS HEALTH AND ENVIRONMENT.’’

By

Maham khan

PIDE2022FMPHILPP14

Supervisor

Mohammad Armughan

M.Phil. Public Policy

PIDE School of Social Sciences

Pakistan Institute of Development Economics,

Islamabad

2024

Pakistan **I**nstitute of **D**evelopment **E**conomics, **I**slamabad

PIDE School of Social Sciences

CERTIFICATE

This is to certify that this thesis entitled: **"Analyzing the Effects of Electronic Waste Recycling on Workers Health and Environment."** submitted by Maham Khan is accepted in its present form by the PIDE School of Social Sciences, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Public Policy.

Supervisor: Mohammad Armughan Signature: _____

External Examiner: Dr. Haroon-ur-Rashid Rana Signature: _____

Head,
PIDE School of Social Sciences: Dr. Hafsa Hina Signature: _____

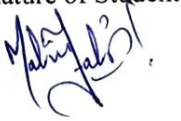
Author's Declaration

I Maham Khan hereby state that my MPhil thesis titled "ANALYZING THE EFFECTS OF ELECTRONIC WASTE RECYCLING ON WORKERS HEALTH AND ENVIRONMENT" is my own work and has not been submitted previously by me for taking any degree from Pakistan Institute of Development Economics or anywhere else in the country/world.

At any time if my statement is found to be incorrect even after my Graduation the university has the right to withdraw my MPhil degree.

Name of Student: MAHAM KHAN

Signature of Student



ABSTRACT

In Pakistan, the rapid increase of Electronic waste is causing serious threats to workers' health as well as the overall environment. The main focus of this study is assessing the workers' health effects and environmental effects stemming from informal e-waste recycling. Secondly, this research aims to analyze the existing policies and practices of e-waste management. The e-waste recycling workers are exposed to job-related stress, physical hazards, and chemical hazards. The risks include chemicals emerging from dismantling and incinerating e-waste scraps such as lead, cadmium, and mercury, physical risks from sharp tools, and psychosocial risks such as stress from working long hours in uncomfortable conditions, Toxic fumes, dusty environment, and extreme noise. Major health risks experienced by e-waste recycling workers include respiratory diseases, eye infections, headaches, backaches, and extensive injuries and ailments that are associated with their working conditions. According to the research, 32.5% of workers have lung problems as a result of dust and chemical exposure, 25% develop eye infections due to inadequate protection, and 20% have skin allergies. Furthermore, 47.5% of the workforce reports that their job has a significant impact on their health and stress levels due to extreme noise, toxic fumes, and long working hours in uncomfortable environments. E-waste recycling workers often experience physical distress, with 52% experiencing occasional discomfort and joint stiffness, while 25% frequently experiencing joint stiffness and muscle pain. According to the study findings, 77.5% of e-waste recycling workers are untrained, uneducated, and unaware of potential hazards. The working conditions in e-waste recycling sites are very poor, there is a need to address issues like inappropriate ventilation, poor hygiene facilities, lack of emergency response plans, and absence of safety procedures for hazardous materials. Among all the types of waste, electronic waste when burned or dismantled randomly causes significant pollution to the environment. When the gases and pollutants found being released into the air harm the surrounding environment and the overall well-being. Based on the study, it is evident that there is a dire need to eliminate the phenomenon of open dumping, open-air burning as well as informal recycling. In Pakistan solving these problems would require increased safety measures and structures for safe recycling. Workers should get occupational safety training on the appropriate use and care of PPE to prevent harm due to toxic fumes and hazardous gases. To address e-waste challenges in Pakistan, the government needs to implement a comprehensive e-waste policy, enforce strict safety regulations for handling hazardous materials, and develop robust infrastructure for safe recycling processes.

Table of Contents

List of Figure

List of Tables

CHAPTER # 01
INTRODUCTION

1.1 Background

Over the years, the consumption of electronics has increased greatly all across the world. The integration of technology into all facets of life has sped up this consumption. Because of this phenomenon, the production of electronic waste, and e-waste has increased significantly worldwide (Perkins et al., 2014). In Pakistan, the rapid increase of Electronic waste is causing serious threats to workers' health as well as the overall environment because of the informal e-waste recycling sector. Electronic waste mostly contains lead, mercury, and cadmium as well as other harmful substances that when treated incorrectly may have far-reaching consequences to both workers health and the environment (Obodoeze et al., 2024). The recycling of e-waste is a rising concern specifically in developing countries like Pakistan. A critical problem is posed through the informal practices of e-waste recycling in Pakistan, with grave health implications for workers facing hazardous exposures and adverse impacts on the environment. This research aims to investigate the complicated dynamics of Informal E-waste recycling methods and their effects on workers' health and environment, emphasizing the serious need to explore sustainable solutions for the well-being of workers and the conservation of the environment. The recycling processes, encompassing collection, sorting, dismantling, and processing, expose individuals to toxic substances, potentially resulting in respiratory problems, skin disorders, and long-term health complications. Simultaneously, the environmental consequences, including air pollution, soil contamination, and water pollution, underline the broader implications of unregulated e-waste recycling practices. The main goal is to shed light on the pressing challenges posed by informal e-waste recycling, emphasizing the need for sustainable and health-conscious alternatives. In a report published by Global E-Waste Monitor, they emphasized the alarming rate at which this material is getting discarded as it poses serious threats to the environment and health of human beings. According to their research, 53.6 million metric tons of e-waste was generated worldwide in 2019. This rate was anticipated to go up to 74.7 million metric tons by 2030. There have to be steps taken towards sustainable management of e-waste in order to reduce the impact on the health of workers and environment (Unitar, 2020).

E-waste recycling processes have been found to differ greatly between more developed countries and ones with fewer resources or regulations (Castro and Bassrin, 2022). In developed countries, formalized e-waste recycling systems exist which are characterized by a formal collection system, recycling plants, and regulatory agencies to ensure proper disposal and recycling of electronic devices (Awasthi et al., 2019). In underdeveloped countries like Pakistan, e-waste recycling is mainly characterized by informal practices, such as backyard recycling and searching for valuable materials and discarded electronics (Shaikh, 2021). In 2022 a total of 560 million kilograms of e-waste was generated in Pakistan, despite this significant amount, the e-waste collection rate was 0%, with no e-waste formally documented as collected (Unitar, 2020). The informal recycling developments are anything but controlled and they endanger workers' health and the environment at large. The current trends in this recycling are aimed at streamlining the whole manufacturing cycle of disposal and finding solutions to the problems (Dutta and Goel, 2022). The major trends in the management of e-waste include the role of technology, the importance of e-waste management, the role of extended producer responsibility (EPR), the establishment of new technologies of recycling, improved collection and systems of recycling, and increased focus on prevention (M, 2023).

Health and environmental impacts of e-waste recycling have gained huge importance around the globe with informal recycling practices being a risk factor, especially in particular regions. Those engaged in e-waste recycling encounter environments polluted with such hazardous substances as heavy metals, brominated flame retardants, and toxic chemicals (Li and Achal, 2022). Such exposure commonly amounts to the development of health issues such as respiratory problems, neurological disorders, as well as other serious health sicknesses (Ackah, 2017). Also, incorrect treatment of e-waste therefore leads to ecosystem contamination, which may include contamination of both soil and water, air emissions, and ecosystem degradation (Ahirwar and Tripathi, 2021). These surroundings and health hazards draw our attention to the importance of effective strategies that can be developed for e-waste management so that such damages can be minimized and the environment and people's health can be safeguarded.

As the fast-paced growth in electronic consumption is scaling e-waste generation, especially in Asia, and particularly in Pakistan. Being one of the world's most densely inhabited states with a steadily increasing economy and a burgeoning middle class, Pakistan has observed

an expansion in electronic device ownership and consumption in the last few years. Consequently, this has generated a parallel increase in e-waste generation, mostly attributed to technological obsolescence, consumer trends, and urbanization (Shaikh, 2021). Nonetheless, the nation's e-waste management is highly underequipped, with only a few existing formal recycling spots and an insufficient control system. Consequentially, a substantial amount of e-waste from Pakistan is handled via unofficial recycling channels which are rather dangerous for workers' health and the environment at the same time (Sajid et al., 2019).

An important role is played by social factors in the behavior of e-waste recycling in households. Factors influencing behavior toward recycling e-waste include the intention of consumers towards recycling e-waste, informational social influence, and normative social influence (Manasi, 2012). People are not going to give up on the usage of electronics. It has become crucial to find ways to properly recycle them. The crisis of e-waste is grave and there is a dire need for consumers to participate in making sure that electronic materials get disposed of properly (Shevchenko et al., 2019). Individuals will be guided from informal disposal to sustainable methods of recycling through an improved understanding of the intentions behind e-waste recycling (Borthakur and Govind, 2017). This will mitigate the impact on the environment in the future and foster the preservation of valuable resources. Pakistan is a developing country. It has a flourishing informal economy and there is a dire need for the challenges related to recycling e-waste to be addressed. The informal sector, often including economically vulnerable and marginalized populations, is central to the processing and handling of e-waste. Also, there are potential risks to the environment and individuals in this sector.

Informal e-waste recycling settlement in Pakistan has an immense role to play where formal waste management infrastructure is absent and there are no policies in control (Shaikh, 2021). The second-hand markets consist of activities like dismantling and sorting electronic devices and recovering precious materials such as metals and plastics for selling or recycling. Nevertheless, it has a number of disadvantaging factors such as the working conditions for the people involved in it, and the environment (Sajid et al., 2019).

The main issue of the absence of infrastructure and regulations in the informal e-waste recycling sector of Pakistan can be taken as the first issue to be addressed. Similar to formal recycling factories available in developed nations, informal recycling operations in Pakistan

always fall short of efficient technology, safety, and proper waste disposal policies and practices (Kazim et al., 2023). For instance, people who work in informal recycling sites may use simple tools like ebony handle hammers and screwdrivers to dismantle electronic devices unsafely while with no protective wear (Ackah, 2017).

The role of the informal sector in e-waste processing as the epitome of the nature of the available limited recycling infrastructure in Pakistan can be highlighted here. informal recyclers, regularly operating in small mechanic shops or outdoor pools, get, sort, and refine E-waste to extract useful components that can be traded on (Imran et al., 2017). This grassroots recycling concept is marked by its rudimentary techniques and traditional practices with close negligence to the safety of workers or environmental protection (Sajid et al., 2019).

However, far from established e-waste management procedures that abide by the established regulations and employ the latest technology to safeguard the environment, informal recycling activities in Pakistan lack oversight and accountability (Rasheed et al., 2022). Formal recycling centers have machinery and processes to handle the e-waste safely, and the risks involved are reduced which would safeguard the well-being of workers and the environment (Awasthi et al., 2019). Nevertheless, informal recycling employing just hands and tools also brings dangers to the health of workers, e.g. exposure to hazardous substances, respiratory diseases caused by inhalation of toxic fumes, and physical trauma (Sajid et al., 2019).

The risks to the safety of workers and the environment in informal e-waste recycling are serious and well-mapped out. Likewise, a study by the Pakistan Council of Scientific and Industrial Research (PCSIR) disclosed that soil samples from e-waste recycling sites in Lahore, Pakistan's capital city, contained high levels of heavy metals such as lead and cadmium (Noreen et al., 2020). Therefore, they cause severe harm to workers' health and the surrounding environment as workers may be afflicted with neurological disorders, respiratory problems, and reproductive issues.

Also, these illegal e-waste recycling activities result in pollution and environmental degradation in Pakistan apart from that. The effect of the release of harmful products as a result of the open burning of electronic devices to recover useful materials in the air, water, and soil is the environmental contamination and potential to harm human health (Awasthi et al., 2019). The leniency of waste management in the informal sector also paves the way for improper handling of

electronic waste which only makes the situation worse when it comes to environmental pollution and ecosystem damage.

Alongside the health and environmental risks, this type of recycling in Pakistan keeps the gap between the poor and the rich (Rasheed et al., 2022). Besides, the sector takes advantage of the unemployed people from underdeveloped countries. Informal recyclers mostly are socially vulnerable people or migrant laborers. They face dangerous working circumstances and low payments. That drives the process of poverty and social injustice (Gollakota et al., 2020). As a result, the informal sector also depends on child labor and unfair employment processes which plague social injustice and human rights violations even more than the informal sector itself.

Among the growing challenges with workers' health and the environment associated with e-waste recycled is the imperative research topic. While the e-waste volume keeps on growing at a global scale, a series of health threats associated with its disposal and recycling are coming to the forefront for workers taking care of the process (Leung, 2019). Poorly equipped informal e-waste recycling activities as the ones found in countries like Pakistan, may place workers at risk of adverse health processes from exposure to poisonous materials without adequate safety gear, including respiratory diseases, neurological disorders, and reproductive diseases. Aside from that, inadequate treatment and disposal of e-waste exacerbates environmental pollution which leads to contamination of soils, water sources, and air, and it poses health hazards to ecosystems and biodiversity (Balasubramanian and Karthikeyan, 2017).

The substantial risk to the health of people and the environment connected with the pursuance of electronics recycling is highly worrying. Accordingly, a properly set e-waste management needs to be adopted. The present research aims to identify specific antecedents and risks faced by laborers engaged in the informal recycling of e-waste, as well as evaluate and appraise present recycling practices of e-waste to contribute towards the development of suitable policies and practices that would minimize risks and sustainably manage e-waste. The other part of the puzzle is e-waste management, without which we cannot achieve the goals of protecting the public health and environmental quality of our surroundings. When the uncontrolled release of toxic substances is left to happen, the fate of human beings and the whole environment horizon can look dismal. Ultimately, this research hopes to join the growing body of knowledge on e-waste

management, generating proof-based data to be of use in decision-making and involved areas to create the best scenarios for workers' health and the environmental aspects at large.

1.2 Research Problem

A critical problem is posed through the informal practices of e-waste recycling in Pakistan, with grave health implications for workers facing hazardous exposures and adverse impacts on the environment. This research aims to investigate the complicated dynamics of Informal E-waste recycling methods and their effects on workers' health and environment, emphasizing the serious need to explore sustainable solutions for the well-being of workers and the conservation of the environment. Workers engaged in informal e-waste recycling often lack adequate safety measures, leading to risks of physical and mental health issues. The recycling processes, encompassing collection, sorting, dismantling, and processing, expose individuals to toxic substances, potentially resulting in respiratory problems, skin disorders, and long-term health complications. Simultaneously, the environmental consequences, including air pollution, soil contamination, and water pollution, underline the broader implications of unregulated e-waste recycling practices. The main goal is to shed light on the pressing challenges posed by informal e-waste recycling, emphasizing the need for sustainable and health-conscious alternatives. While there is research done on the effects of informal e-waste recycling on health and the environment in China, India, Canada, and Ghana, there is little done on Pakistan. Thus, issues concerning workers and the environment may be dissimilar from those existing in other countries. This absence of localized studies proves disadvantageous since it means that policies and, consequently, interventions are not context-specific. Hence, this research helps fill this gap by exploring the informal e-waste recycling system in Pakistan and the necessary information that will inform proper intervention and ensure improvement of the working conditions that affect the health of the workers as well as raise environmental concerns about e-waste disposal.

1.3 Statement of the Problem (SoP)

Based on the narrative of the research problem, the statement of the problem is narrowed into “Analyzing the effect of E-Waste recycling on Workers’ Health and Environment”. The statement of the problem outlines the critical issue of informal e-waste recycling in Rawalpindi and Karachi, highlighting its harmful effects on both the workers’ health and the environment. The lack of safety measures during recycling processes such as Incineration, Acid leaching, Chemical reactions, and Open-air burning puts workers at risk of various health issues. Additionally, the broader environmental impact of unregulated practices underscores the urgency to address this problem. The research aims to explore the complexities of informal e-waste recycling, emphasizing the need for sustainable solutions that prioritize the well-being of workers and contribute to the conservation of the environment.

1.4 Research Objectives

1. Analyzing the informal e-waste recycling methods and their effects on workers’ health and environment.

1.5 Research Questions

1. How do different e-waste recycling methods affect workers' health and environment?

CHAPTER # 02

E-WASTE TRENDS, POLICIES AND MANAGEMENT PRACTICES

2.1. E-waste Trend

According to Unitar "Electronic waste is rising 5 times faster than the documented recycling rate of e-waste". In 2022, a staggering 62 million tons of electronic waste (e-waste) was generated, marking an 82% increase from the levels recorded in 2010.

Table 1: E-waste Statistics in Asia

Total E-waste Generated	30 billion kg | 6.4kg per Capita
Total E-waste Collection Rate	12%
E-waste documented as formally collected	3.6 billion kg | 11.9%
EEE (Electrical and Electronic Equipment) put on the market	56102 kt |12kg per capita

Source: Global E-waste Statistic Partnership 2024

In 2022 Eastern Asia which includes China, Japan, and Korea had the largest generation, totaling 16,000, topped by China's contribution of 12,000. After that South Eastern Asia has the 2nd highest generation of e-waste. And Central Asia has the lowest generation, totaling 400 with Kazakhstan contributing 200. In 2019 Eastern Asia had the highest e-waste generation which was around 13.7Mt and 8.6kg per capita. After that Southern Asia has the second highest e-waste generation which was around 4.8Mt and 2.6kg per capita.

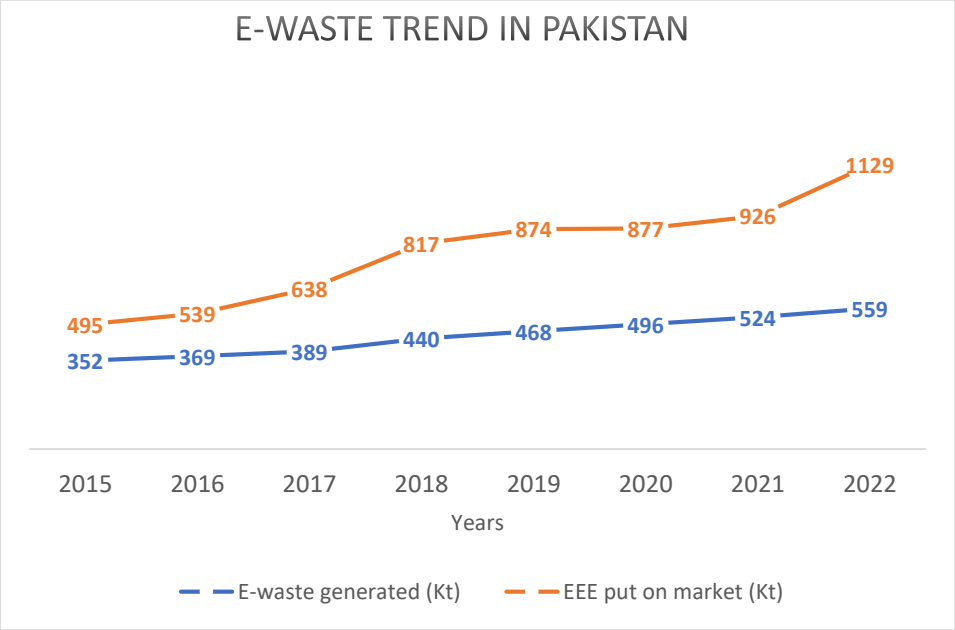
Table 2: : E-waste generated in Asia (2024)

Sub-Region	**E-waste generated (Million kg)**
Central Asia	**400**
Kazakhstan	200
Uzbekistan	130
Turkmenistan	45
Eastern Asia	**16,000**
China	12,000
Japan	2,600
Korea	930

South-Eastern Asia	**4,400**
Indonesia	1,900
Thailand	750
Philippines	540
Southern Asia	**6,100**
India	4,100
Iran	820
Pakistan	560
Western Asia	**3,000**
Turkey	1,100
Saudi Arabia	620
Iraq	270

Source: Global e-waste Monitor Report 2024

Figure 1: E-waste trend in Pakistan (2018-2022)



Source: Global E-waste Statistic Partnership 2024

This figure shows the trend of e-waste from 2015 to 2022 in Pakistan. The blue curve shows the quantity of e-waste generated in kilo tons and the orange curve shows the amount of electrical and electronic equipment that are put in the market. It shows that both have a direct

correlation, the more electrical and electronic equipment is produced, the more e-waste will be generated.

Table 3: E-waste Statistics in Pakistan

Total E-waste Generated	**560 Million kg | 2.4 kg per capita**
Total E-waste Collection Rate	**0%**
E-waste documented as formally collected	**0 kt**
EEE (Electrical and Electronic equipment) put in the market	**1129 kt | 4.8kg per capita**

Source: Global E-waste Statistic Partnership 2024

In Pakistan due to the lack of regulations, e-waste recycling is done informally. The higher expenses associated with formal recycling and stricter regulations in developed nations result in the transfer of genuine e-waste to less regulated developing countries. Although informal recycling is more harmful and hazardous in comparison to formal methods, it continues to be an attractive business in developing nations like Pakistan. Its simplicity and lower financial requirements make it more profitable than formal recycling. Furthermore, it serves as an essential means of earning a livelihood for those involved.

2.2. E-waste recycling and Management Practices Globally

Table 4 E-waste recycling Management practices Globally

Country	E-waste Recycling Management Practices	Citation
United States	Uses advanced recycling technologies, including mechanical and chemical processes; strict regulations such as the Resource Conservation and Recovery Act (RCRA).	(Rene et al., 2021; Kumar and Singh, 2019)
Germany	Implemented Extended Producer Responsibility (EPR) and take-back programs; highly efficient recycling systems; strong regulatory framework under the Waste	(Sthiannopkao and Wong, 2013)

	Electrical and Electronic Equipment (WEEE) Directive.	
Japan	Advanced recycling facilities; extensive producer responsibility laws; promotes resource recovery and circular economy principles.	(Rene et al., 2021; Liu et al., 2023)
South Korea	Strict e-waste regulations; well-developed recycling infrastructure; active participation in international agreements like the Basel Convention.	(Liu et al., 2023)
China	Significant government investment in recycling infrastructure; still faces challenges with informal recycling practices; gradual improvement in regulatory enforcement.	(Priyashantha et al., 2022; Kumar and Singh, 2019)
India	Mix of formal and informal recycling; recent improvements in regulations and infrastructure; lack of widespread awareness and enforcement.	(Gilal et al., 2022; Ahirwar and Tripathi, 2021)
Bangladesh	Predominantly informal recycling methods; limited regulatory framework and infrastructure; significant health risks for workers.	(Priyashantha et al., 2022)
Sri Lanka	Similar challenges to other South Asian countries; developing infrastructure and regulatory measures for better e-waste management.	(Priyashantha et al., 2022)
Pakistan	Predominantly informal recycling; poor regulatory enforcement; lack of infrastructure and awareness; significant health and environmental risks.	(Umair et al., 2016; Shaikh, 2021; Parvez et al., 2021)
Australia	Strong regulatory framework; national recycling initiatives like the National Television and Computer Recycling Scheme (NTCRS); high public awareness.	(Sthiannopkao and Wong, 2013)
Canada	Extensive producer responsibility programs; well-developed recycling infrastructure; significant public and governmental support for e-waste recycling initiatives.	(Rene et al., 2021; Kumar and Singh, 2019)

The discarded electronic devices have given rise to a grave concern all across the globe. 53.6 million metric tonnes of e-waste was generated worldwide in 2019 and this rate was anticipated to go up to 74.7 million metric tonnes by 2030 (Unitar, 2020). There are dire consequences suffered by the well-being of workers and the environment because of the growing concerns regarding the management and recycling of e-waste all across the globe. The need for effective measures of prevention, enhanced systems of collection and recycling, and advanced recycling practices of e-waste now get paid heed by developed countries (M, 2023). However, the health of workers is still a great concern regardless of these advancements because of their exposure to hazardous substances like lead, mercury, and cadmium.

In developed countries, modern and advanced recycling practices are used for the waste management of e-waste. This is not the case in Asia. The concern about the health of workers working in the sites of e-waste recycling (specifically informal recycling) has risen in Asia (Ahirwar and Tripathi, 2021).

(Gilal et al., 2022) conducted a systematic review and attributed the recycling behaviors associated with e-waste in households in India and Pakistan to a lack of knowledge, infrastructure, and awareness about the subject matter. Traditional techniques for the recycling of e-waste are usually adopted in Pakistan and infiltration of the e-waste is usually done through conventional techniques (Gilal et al., 2022). Informal methods of e-waste recycling are used by the businesses doing extraction from e-waste. The benefits here were 1.19 to 1.27 times the costs (Shaikh, 2021). This necessitates improved mechanisms of knowledge, awareness, and enhanced infrastructure and highlights a need for recycling practices that are formal and less harmful to the environment. A link between informal recycling methods of e-waste and poor health outcomes in Pakistan was formed by (Parvez et al., 2021).

(Priyashantha et al., 2022) conducted a study where they found out that in 2019, the production of e-waste all across the globe reached 53.6 million metric tons (Mt). In this situation, 17.4 percent was made up of official recycling and collection. Great contributions were made from Asia, specifically South Asia, with mostly cited sites in Pakistan, Bangladesh, India, and Sri Lanka. From 2019, the production of e-waste in South Asia escalated from 2,621 kt to 4,057 kt in 2019. It was at 2,912 kt in 2016, while in 2017 and 2018, it was at 3,216 kt and 3,641 kt respectively.

The generation of e-waste from South Asia to the generation of e-waste in whole Asia was 13 percent and an annual rise of 1 percent was experienced by South Asia (Priyashantha et al., 2022).

(Sajid et al., 2019)conducted a study where they found that 10 percent of the e-waste generated globally is by the stream of solid waste in Pakistan. The rate of its growth here is 2-3 times higher. However, in comparison to India and China, Pakistan has a significantly lower generation rate of e-waste on a domestic level. Multiple factors contribute to this situation (Iqbal et al., 2015). The poor effects of the trade of e-waste globally on the health and environment were highlighted by the International Labor Organization (ILO). Here risks posed to both workers and the environment were emphasized (ILO, 2012).

One can notice a significant difference in the world when reviewing the e-waste recycling and management practices on the level of development, the regulatory frameworks, and the technological capabilities. (Sthiannopkao and Wong, 2013) highlight e-waste disposal scenarios in developed and underdeveloped nations. These platforms showcase examples like EPR and takeback programs that developed nations go for in order to manage e-waste effectively. Many countries with developed recycling facilities and stipulated rules and regulations concerning the proper disposal and recycling of e-waste fall into this category. On the other hand, developing countries face e-waste management difficulties due to poor resources, no infrastructure, and informal ways of recycling (Sthiannopkao and Wong, 2013).

Electronic waste (e-waste) recycling and management practices adopted in Asian countries, especially Pakistan, pose distinct challenges as well as options. Through the research of Umair et al. (2016), we intend to shed light on both informal electronic waste recycling in Pakistan and the contribution of informal sector workers to the process. To avoid health hazards to workers and environmental pollution, the practices should include proper safety measures and environmental controls. In spite of formal regulations governing e-waste management in Pakistan, enforcement is slack, and hence the issue is not well handled (Umair et al., 2016).

Rene et al. (2021) illustrate technical factors and tendencies in Electronic waste generation and recycling, and resource recovery. They expound on the development of e-waste recycling methods including mechanical, pyrometallurgical, and hydrometallurgical processes. These technologies help get precious metals and materials out of e-waste for resource conservation and the promotion of circular economy principles. Nevertheless, the role of advanced recycling technology may differ

in different areas as a result of dissimilarities in infrastructure investment, regulations, and so on. Yet, the implementation of modern recycling technologies is likely to vary across regions as a result of regional differences in infrastructure, investment, and regulations (Rene et al., 2021).

Liu et al. (2023) establish a global vision for e-waste recycling which focuses on the necessity of international cooperation and joint efforts to tackle the e-waste issue. The research considers the position of the international accords including the Basel Convention and the role of these agreements in controlling the transboundary movement of electronic waste and promotion of sustainable recycling approaches. The international dimension of e-waste also emphasizes the need for the international community to establish standardized protocols and certification schemes such that the responsible management of e-waste is done across borders. On the other hand, the disparities in the e-waste recycling practices and infrastructure among countries are a big problem that requires combined efforts to bridge them and achieve more equitable results (Liu et al., 2023).

Kumar and Singh (2019) endeavor to investigate the e-waste generation, environmental and health impacts, recycling practices, and the status of e-waste laws. The study provides an understanding of adverse environmental and health effects caused by wrong disposal of e-waste such as soil contamination, air pollution, and soil contamination, exposing people to hazardous substances. It also talks about wide-ranging e-waste legislation regulations that cover e-waste management and recycling operations which are environmentally sound. Although few countries have introduced rather strict e-waste regulations, others, including Pakistan, have to struggle with the problem of not having enough resources and institutions for the implementation and control of such laws (Kumar and Singh, 2019).

In general, the literature depicts how e-waste recycling and management patterns are different worldwide, particularly in Asian countries but specifically in Pakistan. In comparison, developed nations sometimes possess a strong system of recycling that is supported by government frameworks. However, developing countries are lagging as they are challenged with limited resources and informal recycling behavior. Technology is the source of resource recovery and eco-friendly recycling, and making this work requires international coordination, uniform standards, and an increased regulatory regime. The e-waste challenge requires a multi-faced approach that holds together government policies, business companies' initiatives, and community involvement

to promote responsible e-waste management and the mitigation of environmental and health hazards.

2.3. Regulations and Policies Internationally and in Pakistan

Table 5: E-waste policies internationally

Country	Policy Name	Policy Description	Citation
United States	Resource Conservation and Recovery Act (RCRA)	Regulates hazardous waste management, including e-waste; mandates safe disposal and recycling of hazardous materials in electronics.	(Patil and Ramakrishna, 2020)
European Union	Waste Electrical and Electronic Equipment (WEEE) Directive	Establishes EPR, setting targets for e-waste collection, recycling, and recovery; bans certain hazardous substances in electronic products.	(Patil and Ramakrishna, 2020)
	Restriction of Hazardous Substances (RoHS) Directive	Restricts the use of specific hazardous materials found in electrical and electronic products to protect human health and the environment.	(Patil and Ramakrishna, 2020)
Japan	Home Appliance Recycling Law (HARL)	Focuses on the recycling of home appliances; mandates manufacturers to collect and recycle specified electronic items; aims to establish a recycling-based economic system.	(Chung and Murakami-Suzuki, 2008)
	Small Appliance Recycling Law	Encourages the collection and recycling of small electronic appliances to reduce e-waste and promote resource recovery.	(Chung and Murakami-Suzuki, 2008)
South Korea	Act on the Resource Circulation of Electrical and	Implements EPR, requiring manufacturers to be responsible for	(Chung and Murakami-Suzuki, 2008)

	Electronic Equipment and Vehicles	the entire lifecycle of their products, from production to disposal.	
	Framework Act on Resource Circulation	Establishes a comprehensive system for waste management, including e-waste, to promote resource circulation and reduce environmental impact.	(Chung and Murakami-Suzuki, 2008)
Canada	Canadian Environmental Protection Act (CEPA)	Governs e-waste management; includes EPR programs requiring manufacturers to take responsibility for the collection and recycling of electronic waste.	(Patil and Ramakrishna, 2020)
	Canada-Wide Action Plan for Extended Producer Responsibility	Aims to harmonize EPR programs across Canada, ensuring that producers are responsible for the end-of-life management of their products, including e-waste.	(Patil and Ramakrishna, 2020)
Australia	National Waste Policy (2009)	Provides a framework for waste management, including e-waste; established the National Television and Computer Recycling Scheme (NTCRS) in 2011 to manage e-waste effectively.	(UNSW, 2016)
	Product Stewardship Act (2011)	Supports the NTCRS and other product stewardship schemes to manage e-waste and other waste products through shared responsibility among manufacturers, retailers, and consumers.	(UNSW, 2016)
China	Extended Producer Responsibility (2011)	Emphasizes the role of manufacturers in the collection and	(Cao et al., 2016)

		recycling of electronic products; aims to increase e-waste recycling rates and improve environmental performance.	
	Circular Economy Promotion Law (2009)	Promotes the reduction, reuse, and recycling of resources, including e-waste, to create a sustainable circular economy.	(Cao et al., 2016)
India	E-Waste Management and Handling Rules (2011)	Places responsibility on manufacturers for the proper disposal and recycling of e-waste; mandates collection, recycling, and disposal of electronic waste; includes EPR policy.	(Bhaskar and Turaga, 2018)
	E-Waste Management Rules (2016)	Updated regulations to strengthen the EPR framework, improve collection targets, and enhance the management of e-waste through environmentally sound practices.	(Bhaskar and Turaga, 2018)
Pakistan	No separate e-waste policy	E-waste is discussed under the National Hazardous Waste Management Policy; enforcement is weak due to limited resources and institutional capacity; informal recycling practices are prevalent.	(Umair et al., 2016; Kumar and Singh, 2019)
Taiwan	Waste Disposal Act (WDA)	Implements EPR, requiring manufacturers to be responsible for the recycling and disposal of electronic products; aims to increase recycling rates and reduce environmental impact.	(Chung and Murakami-Suzuki, 2008)

	Resource Recycling Act	Encourages the reduction, reuse, and recycling of materials, including e-waste, to promote resource sustainability and reduce environmental impact.	(Chung and Murakami-Suzuki, 2008)
Germany	Circular Economy Act (KrWG)	Implements comprehensive waste management policies, including e-waste; mandates recycling and recovery targets; emphasizes the role of manufacturers in waste management through EPR.	(Sthiannopkao and Wong, 2013)
	Electrical and Electronic Equipment Act (ElektroG)	Implements the WEEE Directive in Germany; sets specific targets for the collection, recycling, and recovery of e-waste; ensures manufacturers' responsibility throughout the lifecycle of their products.	(Sthiannopkao and Wong, 2013)
United Kingdom	Environmental Protection Act (EPA)	Regulates waste management, including e-waste; mandates safe disposal and recycling practices; includes EPR requirements for electronic manufacturers.	(Patil and Ramakrishna, 2020)
	Waste Electrical and Electronic Equipment Regulations (2013)	Implements the WEEE Directive in the UK; sets targets for the collection, recycling, and recovery of e-waste; requires producers to finance the end-of-life treatment of their products.	(Patil and Ramakrishna, 2020)
Bangladesh	E-Waste Management Rules	Recently introduced regulations for the management of e-waste; enforcement is still developing;	(Priyashantha et al., 2022)

		significant challenges remain due to informal recycling practices.	
Sri Lanka	National Policy on Waste Management	Aims to develop a comprehensive framework for waste management, including e-waste; focuses on improving recycling infrastructure and public awareness.	(Priyashantha et al., 2022)
Malaysia	Environmental Quality Act (EQA)	Regulates waste management, including e-waste; focuses on reducing environmental pollution through better waste management practices; includes provisions for e-waste recycling and disposal.	(Patil and Ramakrishna, 2020)
	Guidelines for the Classification of Used Electrical and Electronic Equipment in Malaysia	Provides a framework for classifying, managing, and recycling e-waste to reduce environmental impact and promote resource recovery.	(Patil and Ramakrishna, 2020)

The above table shows the international regulations on e-waste and the approaches used by different developed countries as well as developing countries. The inadequate disposal and informal recycling of electronic waste pose significant environmental and human health risks on a global scale. Different legislative frameworks have been implemented to regulate e-waste management and recycling in order to avoid environmental pollution and promote the reuse of resources. E-waste policies varies globally, with different countries implementing different policies to address the growing concerns related to electronic waste.

In Japan, the Home Appliance Recycling Law (HARL) and Small Appliance Recycling Law focus on proper disposal and recycling of electronic products. The main aim is to "establish a recycling-based economic system by reusing parts of collected products such as computers, strengthening collection methods, and introducing new measures to reduce wastes and extending product life span (Chung and MurakamiSuzuki, 2008)". North America and the European Union

has adopted the Extended Producer Responsibility (EPR) approach, holding manufacturers accountable for the entire lifecycle of their products and implementing eco-fees which is used to fund different recycling programs. Australia adopted the National Waste Policy in 2009 and established the National Television and Computer Recycling Scheme in 2011 to manage electronic waste efficiently and effectively (UNSW, 2016). China, in 2011, introduced an Extended Producer Responsibility practice, emphasizing the role of manufacturers in the disposal and recycling of electronic products (Cao et al., 2016). India follows an Extended Producer Responsibility (EPR) policy, placing responsibility on manufacturers for the proper disposal and recycling of electronic waste in the country. India also has The E-Waste Management and Handling Rules. This Regulates the e-waste management at every level of EEE life span from producers to recyclers (Bhaskar and Turaga, 2018).

The study has highlighted the significance of EPR laws or a legal framework that stipulates that the manufacturers are to bear the final responsibility of disposing of their products. Developed countries such as the United States, the European Union Member States, Japan, South Korea, and Canada have adopted e-waste regulations that are full-blown, including well-formulated extended producer responsibility schemes, recycling targets, and bans on the use of some hazardous materials in electronics. These nations have set up collection systems, recycling facilities, and compliance with e-waste laws, which are done through inspection and enforcement. In this study, the importance of effective regulatory measures are emphasized and they are found to bring positive changes in the responsible e-waste management practices and also reduce the environmental and health risks associated with electronic waste (Patil and Ramakrishna, 2020).

On the contrary, developing countries like Pakistan are facing a lack of seeking and enforcing e-waste policies and regulations. Even though the country has put laws in place to deal with the E-waste issue, the enforcement is still weak due to limitations on resources, institutional capacity, and public awareness. Chung and Mukrakami-Suzuki (2008) contrast e-waste recycling systems in Japan, South Korea, and Taiwan from an EPR standpoint and underline the dominant role of government policy in the development of e-waste management practices. On the other hand in Pakistan, the adoption of e-waste regulations is hindered by issues such as existence of the informal recycling practices, lack of infrastructure, and weak enforcement mechanisms. Despite the provisions of the regulatory frameworks, the enforcement of the e-waste policies in Pakistan is hindered by implementation and compliance issues (Chung and Mukrakami-Suzuki, 2008).

Cao et al. (2016) shed light on how the EPR system has affected e-waste recycling in China, considering the involvement of the government, businesses, and the general public. In China, the maker of each electronic product is financially and operationally responsible for collecting and recycling end-of-life electronics. The research reveals that the establishment of EPR in China indeed contributed to the increase of the e-waste recycling rate and environmental performance. Yet the efficiency of EPR systems may fluctuate based on the regulatory framework, participation of all stakeholders, and infrastructure built. In Pakistan EPR mechanisms can be enforced which will encourage manufacturers to design more environment-friendly products and invest in recycling infrastructure (Cao et al., 2016).

In their case study, Bhaskar and Turaga (2018) illustrate how the Indian e-waste rules are impacting the e-waste management measures. India passed the e-waste rules in 2011 and required producers to handle the collection, recycling, and disposal of electronic waste. The evaluation determines how these rules have been realized and how e-waste management practices have been promoted. In spite of the resulting positive changes in the collection and recycling structure after the e-waste legislation in India, obstacles like informal recycling activities, lack of consciousness, and insufficient implementation still exist. On the whole, the study confirms the significance of effective management frameworks, stakeholder involvement, and public information as the core principles of sustainable e-waste management (Bhaskar and Turaga, 2018).

To summarize, the literature discerns that there are differences in e-waste regulatory and policy frameworks among developing countries in contrast to Pakistan. Although established economies have formulated strict regulatory systems and EPR schemes for responsible electronic waste management practices, Pakistan faces the problem of inefficiently administering the e-waste regulations due to limited funding and capacity building. Using measures like improving enforcement mechanisms, engaging stakeholders, and raising public awareness about e-waste management, further improvement of e-waste policies effectiveness could be achieved in Pakistan.

2.4 Review of Relevant Policies of Pakistan

The existing regulations at both provincial and federal levels do not contain particular provisions that are relevant to E-waste management. With the growing e-waste, it is very important to have an efficient and effective e-waste policy to prevent human health and the environment from its toxicity. “There are following policies and laws which focus on environmental concerns

and other hazardous material in the country but none of these policies mentioned e-waste explicitly:

1. National Environmental Policy 2005
2. Pakistan Environmental Protection Act 1997
3. Hazardous Substance Rules 2003
4. Punjab Environmental Protection Act 2012
5. Punjab Hazardous Substances Rules 2018
6. The Punjab Occupational Safety and Health Act 2019
7. Pakistan Penal Code"

Pakistan has committed to various international conventions concerning the handling of hazardous waste. Notably, it is a signatory to the "Basel Convention on the Control of Trans-Boundary Movement of Hazardous Waste and their Disposal" as well as the "Stockholm Convention on Persistent Organic Pollutants". The Basel Convention aims to limit the trans-boundary movement of hazardous waste, specifically preventing its transfer from developed to less developed countries. It highlights reducing both the volume and toxicity of generated waste, promoting environmentally sound management close to the source of generation, and assisting less developed nations in managing their hazardous waste responsibly. Additionally, it commands parties to guarantee adequate disposal facilities for the environmentally sound management of hazardous waste.

"The Stockholm Convention focuses on persistent organic pollutants. POPs, or Persistent Organic Pollutants, are a group of highly toxic and persistent chemical substances that pose significant risks to human health and the environment". The core objective of the Stockholm Convention is to protect human health and the environment from the harmful effects of persistent organic pollutants (POPs).

The World Bank is aiding "Board of Revenue" through the "Punjab Urban Land Records and System Enhancement Project (PULSE)" to facilitate the modernization and digitization of urban land records across the province of Punjab, aiming for efficient and transparent land registration processes. Within this initiative, the project has recognized e-waste generation as a significant ecological and health concern. "Addressing this the "PULSE" project has the following components:

1. Hazardous Material in the E-waste-waste Generation

2. E-waste Legislation
3. E-waste Management
4. E-waste Management plan
5. National Hazardous Waste Management Policy

National Hazardous Waste Management Policy

"The National Hazardous Waste Management Policy (NHWMP)" was endorsed by Pakistan's federal cabinet on June 28, 2022, addressing aspects related to e-waste trade, generation, disposal, and the handling of hazardous waste movement across borders.

CHAPTER # 03

LITERATURE REVIEW

According to Unitar “Electronic waste is rising 5 times faster than the documented recycling rate of e-waste”. The discarded electronic devices have given rise to a grave concern all across the globe. 53.6 million metric tonnes of e-waste was generated worldwide in 2019 and this rate was anticipated to go up to 74.7 million metric tonnes by 2030. In 2022, a staggering 62 million tons of electronic waste (e-waste) was generated, marking an 82% increase from the levels recorded in 2010 (Unitar, 2020). There are dire consequences suffered by the well-being of workers and the environment because of the growing concerns regarding the management and recycling of e-waste all across the globe. The 2024 Global E-waste Monitor offers some fascinating facts about the worldwide production of electronic waste. In 2022, Europe was rated the highest continent in electronic waste generation with 17.6 kg per person on average and it was the most active in e-waste collection and recycling, which diverted 42.8% of the e-waste produced. Countries in Africa followed the trend with the least of e-waste recycled through formal collection of less than 1% (UNITAR, 2024).

In addition, the report identifies the problems of the Asian countries, which are the major producers of Electrical and Electronic Equipment (EEE) available on the market, since they are not able to process the critical components. The most amazing thing is that the bulk of the used e-waste is shipped to East Asia, with the main contributors coming from Western Europe, Northern America, Northern Europe, and Southeast Asia. In North America, e-waste patterns are also regional, with an obvious transfer of e-waste within the region (UNITAR, 2024).

The lack of exact e-waste generation data for Pakistan, India, and Bangladesh in this report ascertains the crucial role e-waste regulation and legislation play in increasing collection and recycling rates. Nations that have fully established electronic waste management systems tend to have good e-waste collection quantities, with average formal collection and recycling rates of 25% in countries that have proper legislation and regulations. Besides others, the review concludes that 81 countries are currently implementing e-waste policies, laws, or regulations, 67 of which are based on the Extended Producer Responsibility principles (UNITAR, 2024).

Forti et al. (2020) cover the most recent research about e-waste generation and recycling processes across the world. The report indicates an increase in waste production by 53.6 million tons from 2019 which shows an 18 percent increase. Not only that, it also shows the importance of e-waste management led to the hazardous nature of the elements of e-waste. The report emphasizes the need for recycling practices to be reviewed because poor waste management can cause environmental and health risks (Forti et al., 2020).

The study pinpoints Asia as the biggest e-waste producer, having 24.9 million metric tons (almost 47% of the global amount) arriving from the region in 2019. This trend of the e-waste boom in Asian countries suggests that it is about time to develop competent e-waste management systems in this region to address environmental challenges and create sustainability. The said report underscores the role of policy frameworks and technologies that facilitate higher recycling rates for e-waste and reduce the ecological impact of e-waste (Forti et al., 2020).

Kumar et al. (2017) deal with waste e-generation, collection, law integration, and recycling globally. The paper makes a case for the enactment of comprehensive laws covering the whole e-waste management process and enhancing recycling activities. The process of E-waste recycling has its problems, namely a widespread informal recycling process, low awareness levels, and a shortage of infrastructure (Kumar et al., 2017).

In the case of Pakistan, e-waste is considered one of the key issues as urbanization and technological advancements continue to gain momentum. It argues that the inadequate setup for proper e-waste management in the country calls for coordinated action to develop sustainable recycling infrastructure and raise public awareness. Moreover, the article highlights the role of cooperation among government bodies, industry leaders, and civil society groups to fight e-waste with success (Kumar et al., 2017).

Both articles have one insight in common, that is, the call for intensive worldwide, regional, and national initiatives to find feasible solutions to the problems caused by the production of e-waste and to deliver effective measures of recycling. The display of the policy mix, inventions in science, and the awareness-raising program leading to fighting the global and regional electronic waste-related environmental and health impacts like that of Asia and Pakistan is shown to be effective.

3.1 Workers' Health Risks in E-Waste Recycling

Several risks affect e-waste recycling workers including heavy metals, persistent organic pollutants, and chemical substances (Okeme & Arrandale, 2019). Such exposures occur while going through the dismantling, shredding, and treatment of electronic waste. (Fischer et al., 2020) also emphasize on health implications of workers in e-waste, and especially the heightened risk of respiratory illnesses, skin diseases, and musculoskeletal complications due to the long exposure to dangerous substances. Such study results highlight the need for safety measures, regulatory interventions, and other steps that would promote the health and well-being of e-waste workers.

Workers in the electronic e-waste recycling process could inhale toxic substances and then develop different dangerous health consequences. Orlins and Guan (2016) focus on informal e-waste recycling methods in China and the detrimental environmental and health impact on workers. They convey the release of workers to pollutants such as lead, mercury, and brominated flame retardants, which then lead to respiratory sicknesses, neurological disorders, and reproductive health complications. Awasthi et al. (2016) also tested the relationship between e-waste recycling and health risks in India, which draws attention to its enormous effect on health. This study is a piece of conclusive evidence that calls for stricter rules and effective occupational health and safety measures that will be used in the field of e-waste recycling to avert health hazards.

The pieces of research show that many projects have examined the health condition of workers in the recycling sector to assess the gravity of the health risks associated with working. Fischer et al. (2020) a comparison between the health outcomes of these e-waste workers with the bystanders with the use of a cross-sectional study. These workers are said to have significantly more respiratory diseases, skin problems, and musculoskeletal disorders and the rates are greater than those who are not exposed. Likewise, Annamalai (2015) focuses on the occupational health hazards associated with informal e-waste recycling in India, indicating a high incidence of respiratory diseases, skin disorders, and injuries. These findings emphasize the need to implement health evaluations, monitor medical services, and provide health services in order to effectively handle the individual health concerns of e-waste recycling personnel.

Ahirwar and Tripathi (2021) go through the process of recycling, environmental and occupational health hazards, and the proposal of some solutions in e-waste management. They recommend the deployment of a recycling process that is environmentally friendly and a well-designed risk management plan to decrease occupational health risks. The writers are proposing

that well-ventilated recycling centers must be established, and workers must be trained and provided with personal protective equipment to achieve safe working zones. Also, technology developments and appropriate policies ensure effective e-waste management practices and the workers' health issues are reduced (Ahirwar and Tripathi, 2021).

Briefly, it is evident through the literature that e-waste recycler workers are highly exposed to various health risks, negative health effects following exposure to toxic materials, and poor health status of people involved in e-waste recycling. It focuses on the roles of sound regulation, improved occupational health, and the need for concrete action as the important actors in e-waste worker's security worldwide.

3.2 Environmental Impacts of E-Waste Recycling

There have been various studies done that look into the process of creating pollution during e-waste recycling activities. Gidarakos et al. (2012) considered the degree of environmental contamination established due to e-waste dumping in Mandoli, India. The research was able to determine the level of heavy metals and other toxic substances in the soil, air, and water near the recycling facilities. According to Sivaramanan (2013), the process of managing and disposing of the e-waste, and the related activities release pollutants to the neighboring ecology such as lead, mercury, and brominated flame retardants. These figures indicate that the government should enforce measures such as sanitation rules and e-waste recycling waste management.

Jain et al. (2023) focuses on the e-waste management problem and its environmental and social impacts. The study is divided into collection, recycling, and disposal of e-waste, which are the basic parts of e-waste management. It introduces the environmental problems caused by e-waste improper management such as soil and water contamination, air pollution, and the wasting of natural resources. In addition, this research has a section on the socioeconomic effects of e-waste management which covers job opportunities in the recycling sector, health risks to workers, and inequality in access to e-waste management services. This study brings to light the urgency of having e-waste management strategies in place that address environmental protection, public health, and social equity among other fundamental issues (Jani et al., 2023).

The contamination of soils, air, and water courses by e-waste recycling activities is one of the major environmental issues. Song and Li (2014) focus on the environmental impacts of heavy metals produced from e-waste recycling in China by conducting a systematic review. Their detections indicate the presence of higher levels of heavy metal contamination in soils, water, and

air samples collected from e-waste sites. And, in Karachi City, Pakistan, Iqbal et al. (2017) present data that show high exposure of the environment and humans to halogens from e-waste pollution as well. E-waste studies often identify widespread environmental media contamination with pollutants released during the e-waste recycling processes as the major source of risks to ecosystems and health of people (Iqbal et al., 2017).

Orlins and Guan (2016) China will be studied in depth in terms of the hazardous technique of the informal e-waste recycling practiced in the country and the approaches applied at the local level to deal with the global environmental problem. They touch on the concerns that go along with informal recycling: e-waste burning in the open and wrong disposal of toxic substances. With this case in point, the role of community-based programs and local supervision in building grassroots knowledge about e-waste pollution is highlighted. This illustrates the requirement for multi-sectoral involvement and effective regulatory enforcement mechanisms to curtail the environmental problems that may be caused by e-waste recycling activities (Orlins and Guan, 2016).

Rasheed et al. (2022) discussed an article that discussed the environmental sustainability of e-waste in developing countries, with a special focus on Pakistan. The evaluation aims to assess the environmental impacts of e-waste recycling methods and identify ways to promote sustainable waste management. The results highlight heavy environmental pollution and health concerns from e-waste recycling activities in Pakistan, showing the need for effective regulation and development of technological infrastructure. Through this case study, several unique issues that developing countries deal with in the process of managing e-waste are highlighted (Rasheed et al., 2022).

An overview of the literature presents the negative side of e-waste recycling, including pollution from the recycling process and soil, air, and water contamination due to the recycling activities. Researchers identify the necessity of imposing strict regulations, community-oriented actions, and environmentally sustainable waste disposal methods to resolve the global environmental issues due to e-waste activities such as in the case of India, China, and Pakistan.

3.3 Best Practices and Solutions followed internationally

The research examines the barriers to the safety of those working in informal recycling, such as exposure to dangerous substances, insufficient or no safety equipment, and no training. Therefore, the authors stress the necessity of best practices including provision of personal protective equipment (PPE), improving ventilation systems, and conducting frequent training and

awareness sessions for the workers. Furthermore, they promote the improvement of the legal framework governing e-waste management in Pakistan and overall compliance with safety standards and the environment for e-waste recycling workers (Imran et al., 2017).

Another study presents the technologies of e-waste recycling; these are mainly targeted at enhancing the safety and efficiency of the procedures. This research emphasizes progress in recycling techniques, including mechanical shredding, pyro metallurgical processing, and hydrometallurgical methods, that allow recovering valuable components from electronic waste with negligible environmental and health effects. These emerging technologies can help improve the safety of workers by reducing exposure to hazardous materials and optimizing production. E-waste recycling plants can reduce pollution and protect the health of workers engaged in the recycling process by adopting safer and more efficient recycling processes (Alam et al., 2022).

Dias et al (2019) study the best e-waste recycling practices in developed countries, with Australia as a case study. The research suggests some of the strategies that Australia has utilized to make e-waste recycling to be safe and sustainable. These thus include the development of collection and recycling programs, advertising campaigns, and regulatory frameworks that control the management of e-waste. The authors give special attention to the producer responsibility mechanism which requires manufacturers to take charge of their product’s end-of-life management and consequently promotes environmentally friendly recycling. Developed countries including Australia show the world how most of the environmental and health issues along with electronic waste can be controlled by implementing best practices in e-waste recycling (Dias et al., 2019).

Briefly, the literature recognizes different ways and solutions of improving workers' safety and promoting sustainable e-waste recycling practices globally. Measures include following good recycling practices in e-waste facilities, introducing the use of new technology to enhance efficiency and safety, and establishing regulatory frameworks to improve e-waste management. Through such measures, countries can resolve the environmental and health risks associated with e-waste recycling and thus shift towards a more sustainable and responsible manner for electronic waste management.

3.4 Gaps in Research and Future Directions

From the available literature on e-waste recycling, some gaps in research and future directions including worker's health, the environment, policies, and practices in the country of Pakistan can be highlighted. First of all, a noticeable disconnect exists in recognizing health risks for workers

using unconventional or informal e-waste recycling methods. Even though a few studies have assessed the general health risks in relation to e-waste recycling, there is a scarcity of research that focuses on specific informal recycling practices that are common in developing countries like Pakistan. The study fills this gap by studying in detail the informal e-waste recycling methods employed by workers in Pakistan, conducting an analysis of the associated health effects, and finding out the interventions able to alleviate risks. Secondly, the lack of research studies on the environmental effects of e-waste recycling in Pakistan is appealing, especially in context of the informal recycling operations. The studies have already talked about the environmental pollution caused by e-waste recycling worldwide but it is necessary for localized research so that the unique environmental issues faced by Pakistan due to the informal recycling sector can be known, especially at the places where recycling is done. Besides, there is a lack of studies about the effectiveness of the current policies and management practices that is mainly for electronic waste in Pakistan. While some of the studies focused on e-waste regulations and practices in developed countries, there is very little knowledge about the implementation and enforcement of e-waste policies in Pakistan. This research fills the gap by conducting a thorough analysis of the e-waste management policies and practices in Pakistan coupled with their effectiveness in curbing health and environmental problems and highlighting key areas of improvement.

The studies talk about the health and environmental impacts of e-waste recycling, but there is no clear consensus on the broader aspects like the livelihoods of informal recyclers and the upliftment of the community. This will be achieved through the analysis of Pakistan's e-waste recycling's socio-economic dynamics, including its effect on livelihoods, income generation, and social inequalities. To sum up, this research examines the effects of e-waste recycling on workers' health and environment in Pakistan will take up several key voids in the existing literature. Through the in-depth assessment of the informal recycling methods of e-waste by looking into their health and environmental impacts, reviewing current policies and practices. This research study provide valuable information that can inform the policy and practice of e-waste management. This study is conducted through intensive empirical research and analysis which will contribute to solving the current e-waste recycling problems and promote sustainable and responsible practices in Pakistan.

CHAPTER # 04

METHODOLOGY

4.1 Research Strategy

The basic nature of the data is primary. The study follows a descriptive qualitative research strategy as it provides a better understanding and knowledge of the problem through first-hand experience which helps us gain an in-depth understanding of the problem.

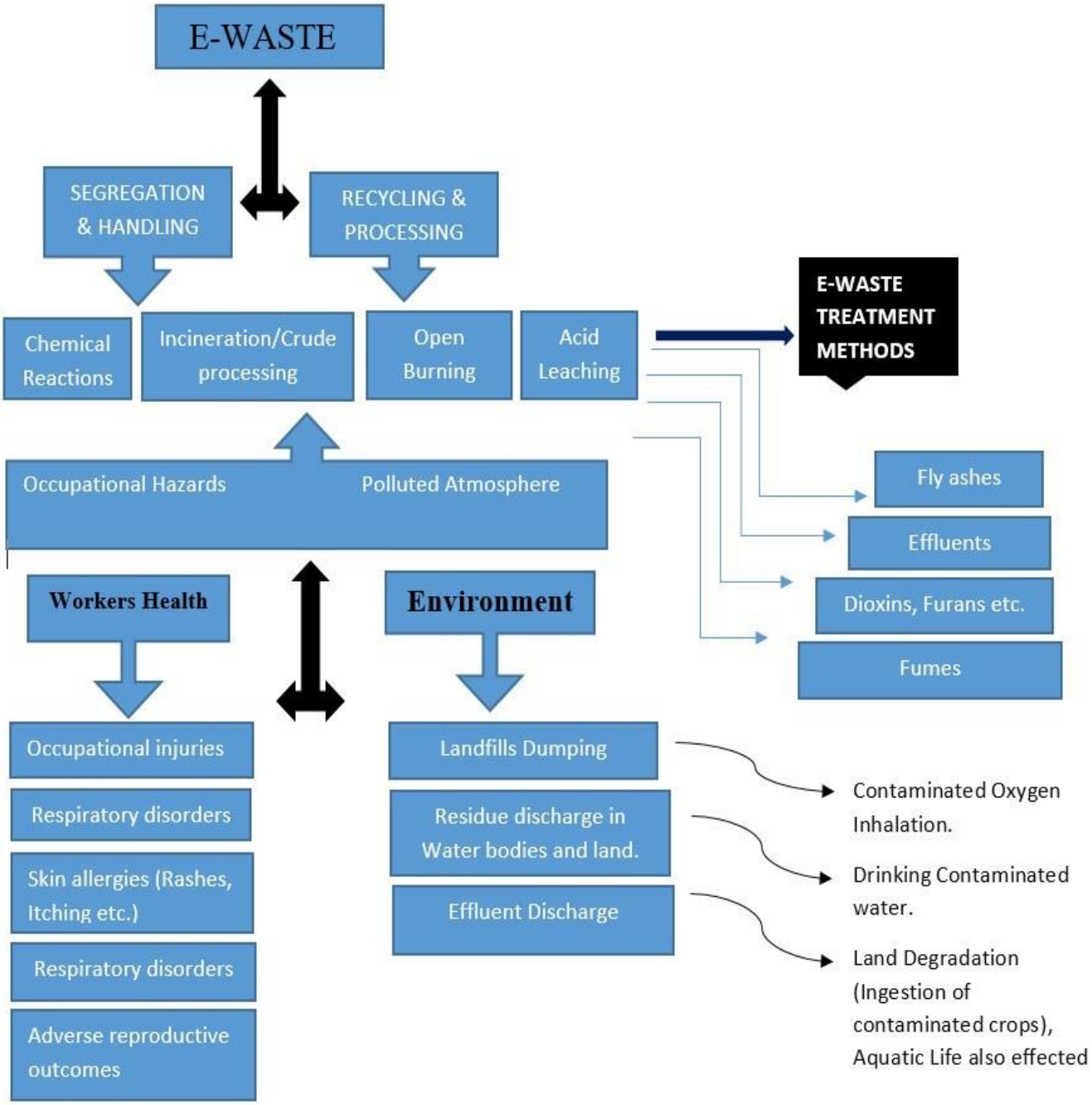
4.2 Research Design

Field data collection has been done to collect data from our key respondents through semi-structured questionnaires and interviews to achieve the goal of this study.

4.3 Conceptual Framework

For better understanding of this research problem, The framework focuses on e-waste recycling methods, their effects on worker health, and environmental consequences. It aims to understand how these are interrelated. The initial segment focuses on e-waste handling procedures which include e-waste collection and recycling methods, and adherence to safety regulations which form the basis to assess impacts on workers' well-being and the environment. Worker health analysis involves different physical indicators such as (respiratory issues, chemical exposure, and work-related injuries) and mental aspects (stress, anxiety, depression) among those in e-waste recycling and handling. It also focuses on environmental consequences, measuring pollution levels in air, soil, and water (assessment of the area where e-waste is dumped). The study also look at, how e-waste is disposed of and how its surrounding vicinities are getting effected.

Figure 2: Conceptual Framework



The figure illustrates the cycle of electronic waste, starting from the top where E-waste undergoes different processes of collection, Segregation, sorting, Dismantling, etc. This figure outlines how e-waste is processed, resulting in a threat to both workers' health and the environment. Various informal methods like chemical reactions, crude processing, incineration, acid leaching, etc. employed in e-waste recycling produce harmful byproducts, including dioxins, furans, fly ashes, fumes, effluents, and other pollutants. This not only leads to occupational hazards such as stress, injuries, and respiratory disorders among workers but also contributes to environmental pollution. Improper disposal practices, such as dumping in different landfills and dumping in water bodies, result in the contamination of the surrounding air, water bodies, and land, impacting both human and environmental well-being. The Residue discharge in water bodies and land also contaminates water and land, affecting agriculture and the aquatic food chain. Contaminated water affects aquatic life, which is a food source for humans. The cycle completes with the human population being affected by these several routes of exposure. The implication is that improper disposal and processing of e-waste have extensive effects.

4.4 Unit of Data Collection

To find our objective, our unit of data collection includes workers involved in e-waste recycling and handling, scrap dealers, Refurbishers, E-waste storage facilities, and warehouses. This involves a semi-structured questionnaire containing open-ended and closed-ended questions to understand their experiences, health conditions, and hazard exposure. Different scrap dealers and refurbishers has been interviewed to understand the whole vertically integrated chain of electronics scrap from scrap dealers to brokers and then recycling units, this provides a nuanced understanding of the e-waste recycling sector. Secondly, this study looked at the policies that are followed in Pakistan for e-waste recycling and management.

4.5 Method of Data Collection

To achieve the goals of the research, several methods for field data collection is used including, interviews and questionnaires. A semi-structured questionnaire containing both closed-ended and open-ended questions is used based on previous studies on E-waste recycling and management. The tentative questionnaire is comprised of qualitative and quantitative data variables. As regards the data collection sources are concerned, (the desired data from scrap dealers and E-waste second-hand equipment sellers) through interviews; and also the data from different

workers through semi-structured questionnaires is collected to see how their health is affected. This study uses snowball sampling techniques to study the effects of e-waste recycling on workers' health and the environment. This approach helps us to access the potential respondents within the e-waste recycling sector, acknowledging the presence of a vertically integrated channel involving retailers, wholesalers, scrap dealers, and recyclers.

4.6 Location

I've chosen Rawalpindi and Karachi as my data collection sites. My data collection commenced in Rawalpindi, where I conducted interviews with electronics refurbished equipment shopkeepers. Through these interactions, I got to know about the network of e-waste scrap dealers located in the Taj Mahal Plaza. These electronic scrap dealers informed me that the segregated e-waste is subsequently sent to Lahore and Karachi for further recycling. As a seaport, Karachi receives containers of e-waste from all over the globe, mainly United States, the United Kingdom, Japan, and several European nations. Once the e-waste containers are cleared from the port, the e-waste is transported to warehouses, where scrappers purchase it by weight. Depending on the materials, the e-waste is recycled informally it includes either dismantling, burning, or dumping. Consequently, I extended my data collection to include Karachi, where I interviewed two well-known electronic scrap dealers. From these dealers, I got to know about the Sher Shah market, which is a major hub for large-scale e-waste recycling. Karachi as a city is marked by its uncontrollable and bustling commercial activities, such as the electronics grand bazaar near the CITY CENTER. This is a vertically integrated chain from electronics scrap dealers to various brokers and recycling units. To thoroughly explore this chain, this study employed a snowball sampling approach to identify and interview key respondents, beginning with electronics shopkeepers in Dubai Plaza, Rawalpindi ending up with workers who are directly involved in e-waste recycling in Sher Shah market Karachi.

4.7 Sampling Technique

This study use snowball sampling technique to study the effects of e-waste recycling on workers' health and the environment. This approach helps us to access the potential respondents within the e-waste recycling sector, acknowledging the presence of a vertically integrated channel involving retailers, wholesalers, scrap dealers, and recyclers. This approach helps us to reach individual workers more effectively by utilizing existing connections within this complex network.

4.8 Sample Size:

My data collection commenced in Rawalpindi, where I conducted interviews with electronics refurbished equipment shopkeepers. Through these interactions, I got to know about the network of e-waste scrap dealers located in the Taj Mahal Plaza. These electronic scrap dealers informed me that the segregated e-waste is subsequently sent to Lahore and Karachi for further recycling. However, the main e-waste recycling hub is in Karachi. So my sample size of 40 e-waste recycling workers is from Karachi Shersha, where all the e-waste recycling is done informally. For this study data collection started from IT Scrap & Refurbished equipment sellers in Rawalpindi, then scrap dealers, and through these e-waste scrap dealers, we reached out to our potential respondents who are e-waste recyclers in Karachi.

Table 6: Sample size and Data Collection Units

Key Respondents	**Sample Size**	**Location**	**Activity**
IT Scrap & Refurbished equipment seller	4	Rawalpindi Dubai Plaza	Buying/selling of second-hand ICT equipment and refurbishing. Manual dismantling of e-waste.
Electronic Scrap Dealers	4	2 from Rawalpindi, Taj Mahal Plaza 2 from Karachi, Near the Buffer zone	Manual dismantling of e-waste, Refurbishing, and extraction of valuable items from e-waste.
Recycling Workers	40	Karachi, Sher Shah Market	Buying/selling of e-waste. Manual dismantling, burning of cable/e-waste, selling of scrap, recycling of batteries, and precious metal extraction.

Recycling Workers Sample Size in Shersha Karachi:

In total I have visited 8 recycling units in Shersha Karachi, out of these, 2 recycling units were not willing to answer any of my questions. The sample size of workers interviewed from the rest 6 recycling units is shown below;

Table 7: Sample size of e-waste recycling workers

Recycling Units	No. of workers Interviewed
1	6
2	6
3	6
4	6
5	8
6	8
Total workers	40

4.9 Interviews with e-waste storage Workshops and Scrap Dealers:

The above table shows the stakeholders that were interviewed to reach our potential respondents and the open-ended interview guide that was used. To understand this vertically integrated chain from electronics scrap dealers to different brokers and then recycling units this study uses a snowball sampling approach to reach our potential respondents. We started our data collection by interviewing electronics shopkeepers in Dubai Plaza Rawalpindi. Information I got from them was that whatever scrap is saved from their shop, they sell it to scrap dealers. Scrap dealers are located in Rawalpindi Taj Mahal Plaza.

Our second key respondent for the interview was scrap dealers. 2 scrap dealers from Rawalpindi and 2 scrap dealers from Karachi were interviewed. It was a semi-structured interview. The main focus was on the quantity of e-waste they deal with daily, the types of e-waste, the Assessment Technique to assess the condition and value of incoming e-waste items, and the process of sorting and segregating e-waste items at their facility.

The first interview was with a Bajwa Scrap dealer from Rawalpindi Taj Mahal Plaza. The respondent mentioned "On average, our facility collects 40 to 50 Lacs of e-waste per day, although this amount fluctuates depending on various factors. The business is in partnership with two other individuals. Mainly, the electronic equipment we purchase includes computer screens, CPUs, printers, LCDs, Photostat machines, and laptops. However, certain categories of e-waste pose greater challenges due to their composition and complexity, such as devices containing hazardous materials like mercury, lead, or cadmium, and products with intricate designs or integrated components like smartphones or tablets. To assess the condition and value of incoming e-waste items, we purchase scrap by weight, with each component having a different rate depending on its value. Motherboards and CPUs are particularly valuable due to their content of precious metals like gold, silver, and copper, which can be extracted through specialized processes. Integrated circuits and other electronic components are harvested for reuse or refurbished for resale, while copper wiring is reclaimed and reused. The scrap we purchase mainly comes from shops and government auctions, where rates are determined per kilogram. Our process involves a team of over 50 employees who disassemble and segregate the e-waste, extracting valuable components for resale or refurbishment. The remaining scrap is sold to brokers who supply it to different recycling facilities mainly in Karachi and Lahore."

The second interview respondent was a scrap dealer from Rawalpindi whose workshop was in Taj Mahal Plaza, Rawalpindi. He mentioned that he mainly deals with computer equipment only. He mentioned that all the employees at their shop are involved in disassembling and recovering valuable things from this scrap that can be refurbished and sold at a good price. The scrap is purchased and sold in kilograms, and everything has a different rate. They deal with 20 to 30 Lac of electronics scrap each day, but this cost keeps on fluctuating depending upon different factors. Sometimes, they don't find any reasonable scrap, so on those days, they work on refurbishing and reassembling previous waste at their workshop. This respondent mentioned that the scrap that they purchase is mostly from auctions or sometimes it's imported scrap. Different

electronics scrap containers come from abroad, from Dubai, Sharjah, and several other countries, and they come to Karachi. Then people go there and buy containers, who further sell the scrap to different dealers and some refurbished equipment to shopkeepers who then sell it as used goods. The scrap is sold per kilogram. Every piece of equipment has a different rate. For instance, printers are sold at 950 PKR per kilogram. The motherboard extracted from P4 is sold at 1700 PKR per kilogram. The older versions "P1, P2, and P3" are sold at 2700 PKR per kilogram. The hard drive is sold at 900 PKR per kilogram. The laptop boards are also extracted by the employees and sold at different prices depending upon their version. Older versions of boards are sold at 6000 to 8000 PKR per kilogram. The older versions are sold at a higher rate because the amount of gold used in them is comparatively higher. This respondent mentioned that he has a team of 20-plus employees. Most of the buyers are big brokers or foreigners who purchase this scrap equipment and then recycle it.

The third respondent was a scrap dealer from Karachi. He mentioned that he purchases the electronics scrap in auctions by bidding, the one who bids the auction purchases the e-waste in Kgs. He mainly purchases computer and Android mobile scrap. 25 plus workers are working at their workshop disassembling the electronic equipment to different parts. Plastic is separated and sold to plastic industries. Processors and boards are further sent for recycling and extraction of valuable materials like silver, gold, and copper to the “Sher Shah” electronic scrap market where all the electronic scrap is sent for recycling. Some valuable chips are exported to China for further processing which can't be done here in Pakistan. Daily they deal with 50 lacs of electronic scrap but according to them, this cost varies each day.

The fourth interview respondent was an IT scrap dealer from the Karachi Buffer Zone. At his workshop, electronic scrap is collected from various sources such as the Sher Shah electronic scrap market and auctions of different companies and organizations, mainly consisting of mixed equipment like CPUs, printers, LCDs, computer screens, and ACs. Throughout the year, there are fluctuations in e-waste collection. This respondent mainly deals with computer equipment, with all employees engaged in disassembling and recovering valuable components for refurbishment and resale. Assessing the condition and value of incoming e-waste involves evaluating different rates for items, particularly those containing copper and gold, with RAM being mainly valuable due to its gold content. RAM is sold at 20,000 PKR per Kg these days. Different cables and wires are one of the sources of copper which is extracted by their workers and then sold to different

buyers. Out of 1kg wire or cable waste 0.5kg copper can be easily extracted. Most of the collected e-waste is segregated, and valuable components are sold to recyclers, primarily in Sher Shah Market, where further recycling processes occur. This e-waste business is very profitable because nothing is wasted. The respondent mentioned that at his workshop he had a team of five employees involved in the segregation process of IT scrap.

CHAPTER #5

FINDINGS AND DISCUSSIONS

5.1 DEMOGRAPHICS OF RECYCLING WORKERS

Table 8: Demographics of recycling workers

GENDER	**TOTAL NUMBER**	**PERCENTAGE**
Male	37	92.5%
Female	3	7.5%
AGE RANGE	**TOTAL NUMBER**	**PERCENTAGE**
10-20	3	7.5%
21-30	13	32.5%
31-40	14	35%
41-50	8	20%
51-60	2	5%
EDUCATION LEVEL	**TOTAL NUMBER**	**PERCENTAGE**
Illiterate	17	42.5%
Primary schooling	19	47.5%
Secondary schooling	4	10%
Matriculation	0	0
Intermediate	0	0
INCOME LEVEL	**TOTAL NUMBER**	**PERCENTAGE**
Less than 10,000	0	0
10,000 to 15,000	2	5%
15,001 to 20,000	12	30%
20,001 to 25,000	11	27.5%
25,001 to 30,000	12	30%
35,001 to 45,000	3	7.5%
More than 45,000	0	0

Number of years working in e-waste recycling

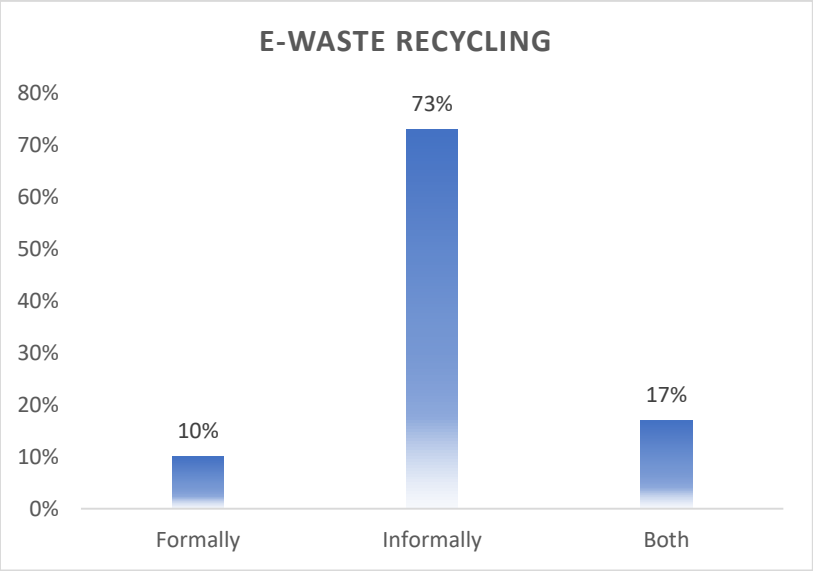
The following data shows the yearly experience of the workers who engage in the recycling of e-waste. This shows that 52.5% of the workers have relatively long experience in e-waste recycling, they have worked for seven years and above in the same field.

Table 9: Number of years working in e-waste recycling

Number of years	Number of workers	Percentage
Less than 1 year	1	2.5%
1-3 years	8	20%
4-6 years	10	25%
7 or more years	21	52.5%

5.2 Informal E-waste Recycling in Sher Shah Karachi and quantity of e-waste recycled/day

Figure 3: E-waste Recycling Formal Vs Informal



The graph illustrates the distribution of workers involved in e-waste recycling across three categories: There are different types of recycling: formal or legal, informal, and both. It proves that 4 individuals (out of 40) have only worked in formal recycling, 29 individuals (out of 40) have only worked in informal recycling, and 7 individuals (out of 40) have participated in both of them. This data also reveals that a vast majority of workers participate in informal recycling activities. A clarification on this is that the 47 percent that responded that they had a hand in the formal recycling did that based on the availability of a recycling plant that involves the burning of e-waste. As much as these recycling units are in existence, none of them are approved for

government recognition, implying that the practices in these units may not be in compliance with the law. As a researcher for this study what I have observed is that all the e-waste recycling is done informally, with no rules and regulations.



Quantity of waste recycled each day:

Table 10: Quantity of e-waste recycle each day

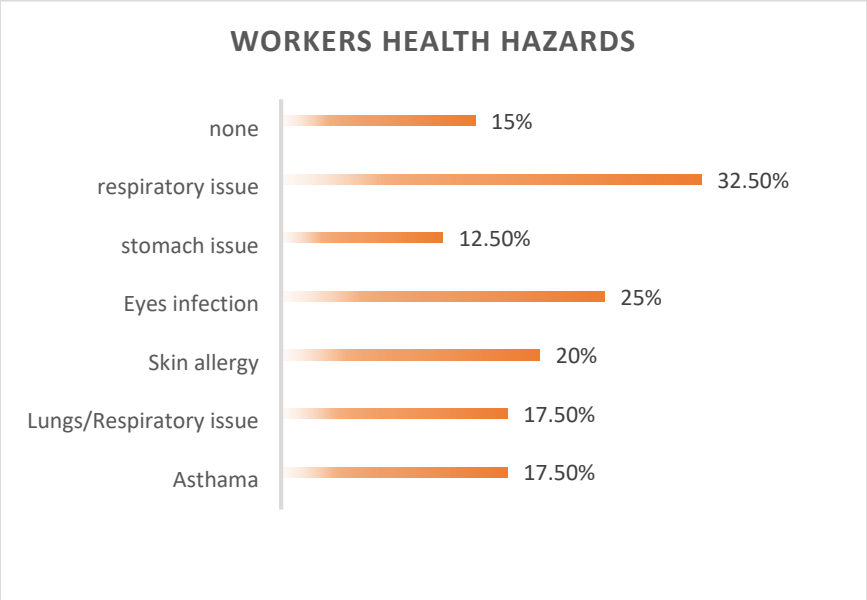
Burning	**Dismantling**	**Segregation**		**Extraction**
2-4kg per worker/ hour	1-2kg per worker/hour	0.5-1kg per worker/hour	2-3kg per worker/hour	0.5-1 kg per worker/per hour
Burning of wires, cables, circuit boards etc.	Dismantling PCs, laptops, keyboards, printers etc. to remove valuable parts like processors, RAM chips, capacitors from circuit boards	For small equipment like chips, cards etc.	For medium and large equipment.	Extraction of precious metals like gold, silver, copper from different chips, Boards etc.

5.3. Workers Health Issues:

The given graph presents information concerning the various health risks faced by recycling workers in the informal e-waste recycling units. It shows that 32.5% (13 workers) were facing breathing issues, this respiratory disorder is mainly from dusty environments and toxic chemicals. Eye infections are another common ailment affecting 25% of the workers which mainly results

from poor ventilation, dust, and other airborne particles. Skin allergy, for example, itching and redness are prevalent in 8 workers and aggravated by direct contact with hazardous material at 20%. Furthermore, chronic/inflammation lung/respiratory diseases and asthma are also faced by 17.5% of the workers, which they complained suffered from recurrent coughs and breathing difficulties. Stomach problems were also common among these workers, while 15% of the workers (6 workers) did not complain of having any health issues at all, and said that they do not have any form of health challenges. This data shows that a considerable percentage of informal e-waste recyclers in developing nations suffer from various diseases, with respiratory diseases as the most common, and other diseases such as eye irritation, skin rashes, lung diseases, and asthma. These health complications are blamed for on some factors that include working conditions, physical demands, and exposure to dangerous commodities in the recycling work arena.

Figure 4: Health Hazards among recycling workers

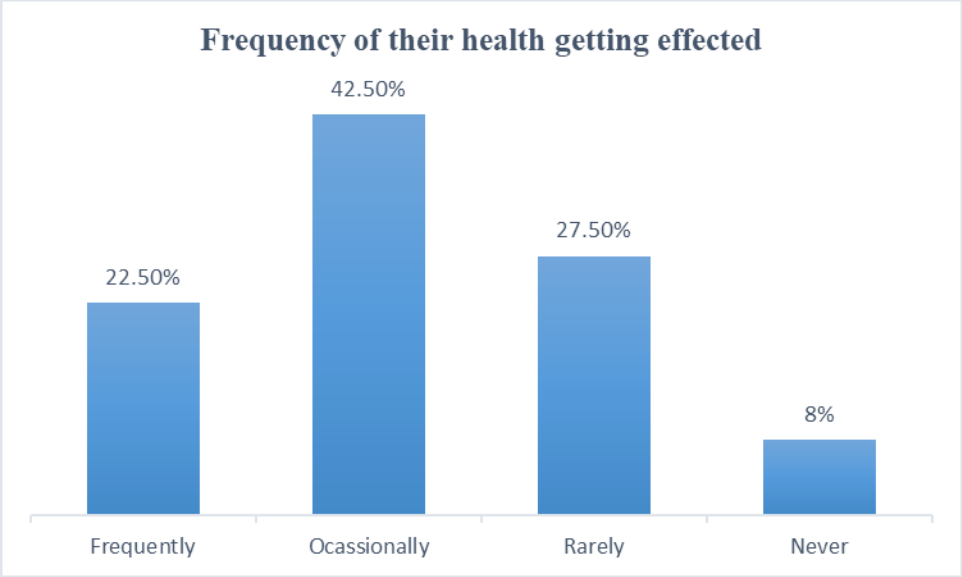


Analyzing the information presented in the graph below, it is possible to gain some understanding of how often various health issues, including respiratory disorders, eye infections, and skin diseases, affect workers, who are involved in informal e-waste recycling. A significant portion, 42.5% (17 workers) claimed that they occasionally experience these health issues. 22.5% (9 workers) claimed that they frequently experience these health issues. Only 7.5% (3 workers) showed that they have never had such health issues.

It was understood that due to dust and chemicals used in the recycling process, the workers mostly suffered from respiratory disorders and lung disease complaints of constant cough and

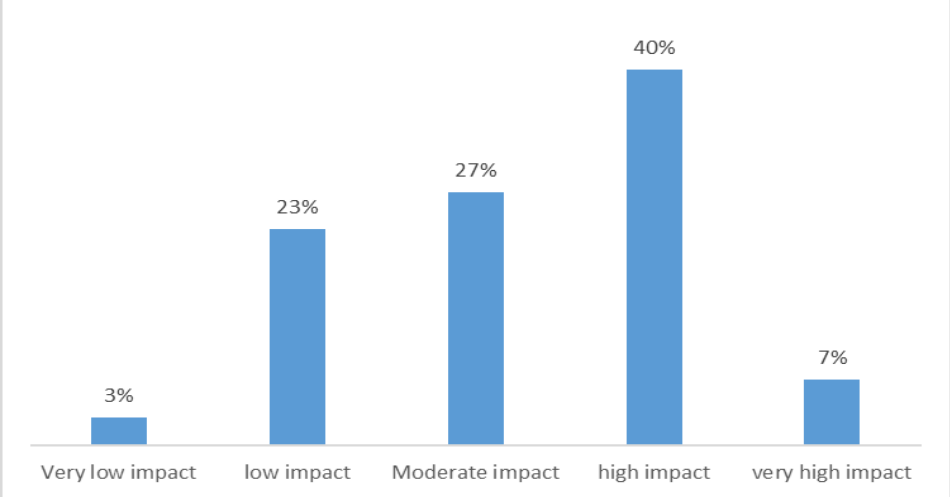
respiratory problems. Eyes get infected frequently including reoccurring eye infections due to emissions of bad air and dust. With skin allergy, the itching and redness of the skin become worse with direct contact with dangerous substances. Further, bending and lifting items, machine parts or even discouraging medical products entail excessive pulling of back muscles that causes severe back pains to some of those employed. The overall effect demonstrates a reduction in general health with complaints indicating tiredness, and headaches, this is due to harsh working conditions, lack of safety precautions, and regular exposure to chemicals.

Figure 5: Frequency of their health getting effected



a) **The overall impact of E-waste recycling on workers health and stress levels**

Figure 6: Overall impact of E-waste recycling on workers' health and stress levels

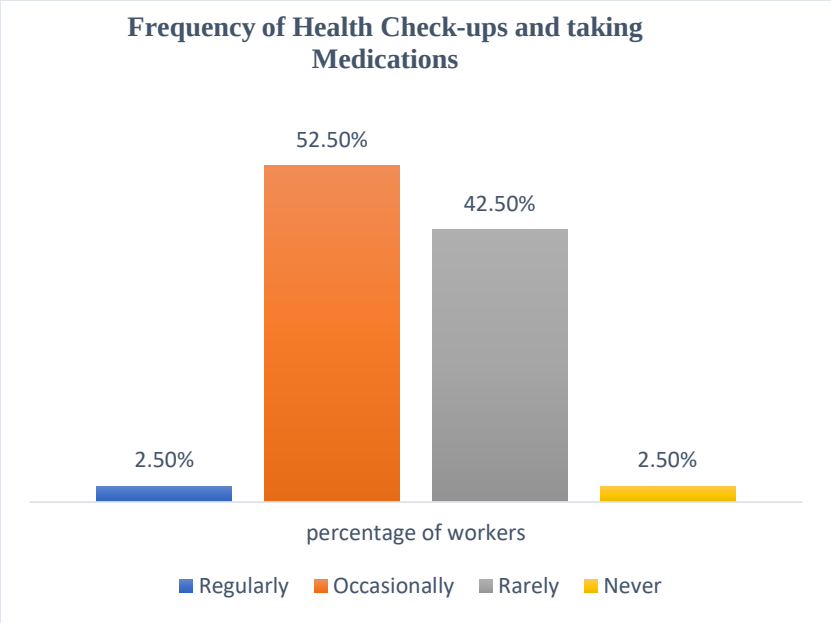


The majority of participants rated their experience, (4 or 5), with 47.5%, showing a strong impact of their recycling job on their health and stress levels. 27.5% of respondents showed a moderate impact of their job on their overall health and stress levels. However, a small proportion (25%) rated it as a low impact of e-waste recycling on workers' health and stress levels. The respondents that show they are having a low impact give a rather negative view that while some workers may not be so much affected by the recycling processes and harsh working conditions, they are few in number. These respondents might include those who have relatively less demanding tasks or involve exposing themselves to dangerous situations or dealing with highly stressful conditions, or they may perhaps be better equipped to handle the toxic hazardous e-waste recycling. This is a relatively high figure expressing the share of workers who complain about high health and stress levels, equal to 47. 5%. This may be because of various aspects inherent in the process of e-waste recycling including working with hazardous materials, exposure to those products which cause mechanical pressure on the human body, and mental challenges of dealing with potentially dangerous products.

b) Frequency of Health Check-ups and taking Medications

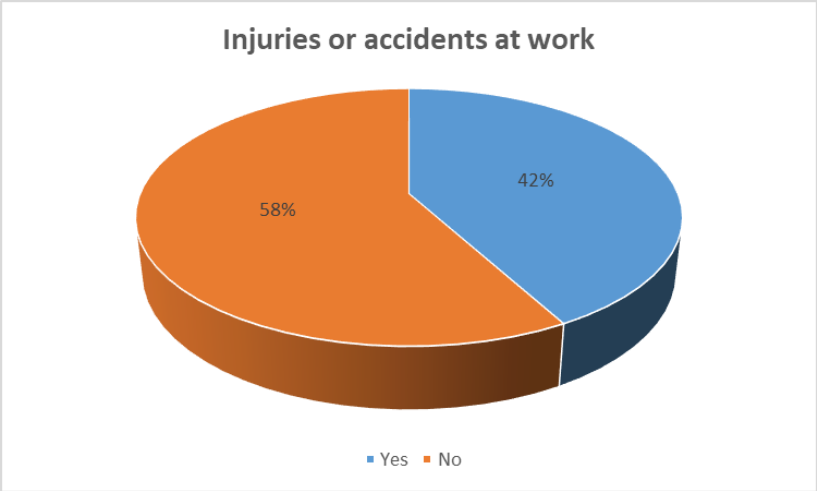
The bar chart labeled ‘’Frequency of Health Check-ups and taking Medications’’ shows the workers’ health management outcome within e-waste recycling. A majority, 52. 5% answer affirmatively but state that they only do so at random or when they feel a symptom arising or a disease developing, 42.5% of respondents stated that they rarely go to health check-ups, this shows that they do not give much attention to health as to show that many workers are not fully aware with their health status. Only 2. 5% of respondents routinely undergo certain health check-ups and always take their medications while the other 2. 5% never do so. The details of these patterns may be explained by the respondents’ inability to receive necessary health check-ups, their general inadequate knowledge of the effects of e-waste recycling on health, and Financial constraints. Respondents have mentioned that visiting government hospitals for medical check-ups is so hectic for them, so they prefer not to go until or unless symptoms are severe. One respondent mentioned that “at times I prefer not to go, neither I have time for it, we only have 1 holiday, that is also spent in buying groceries for home and some other work”.

Figure 7: Frequency of Health Check-ups and taking Medications



c) Injuries or Accidents at Work

Figure 8: Injuries or Accidents at Work

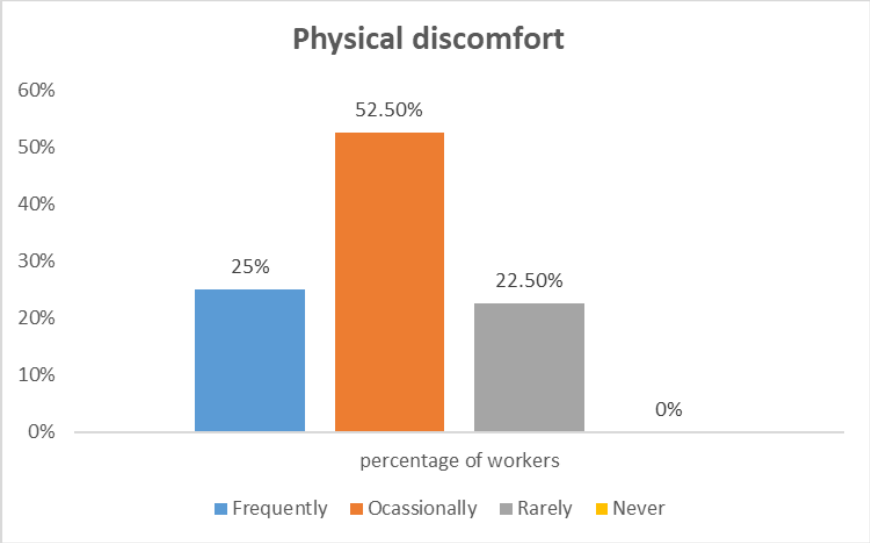


From the given data the workers are divided into 2 categories, first one is the number of workers in the e-waste recycling industry who have been involved in an accident or experienced an injury or not as highlighted below. Out of the total respondents, 42% of workers have responded to having experienced injuries or accidents at the workplace. 54% out of the total number of workers have not incurred injuries or accidents at the workplace. Thus, it is not a coincidence that this experience of workers has shown that one is likely to get cuts and bruises every time he or she is handling and separating sharp objects as this is a common hazard faced when recycling e-waste.

Employees within this sector are exposed to risks from sharp items such as broken glass pieces or metal edges, or any other electrically conductive material within the electronic devices. Because of this, it is important in this sector to embrace safety measures, equip the workers with knowledge of hazardous materials in e-waste, and most importantly necessary protective gear and tools to prevent possible injuries and mishaps.

d) Frequency of workers experiencing physical discomfort

Figure 9: Frequency of workers experiencing physical discomfort



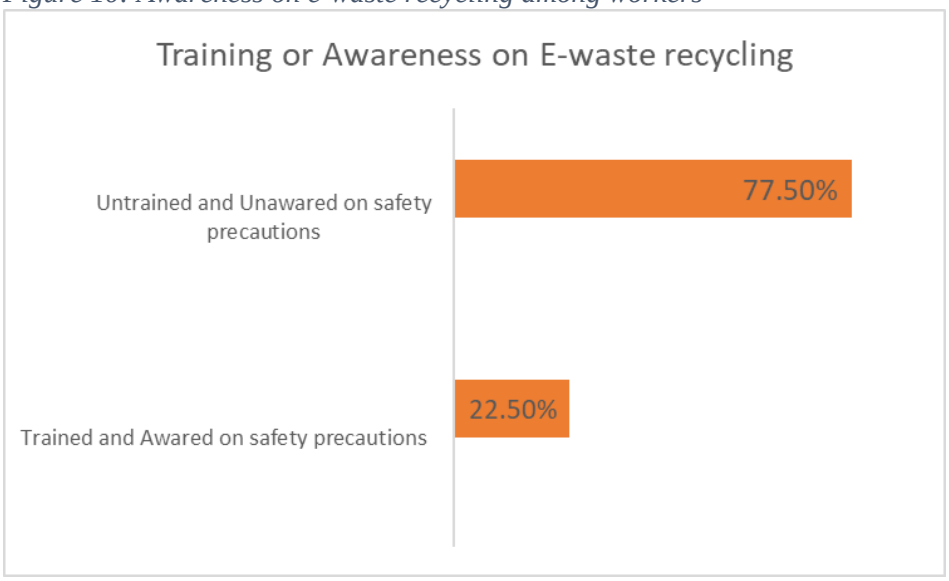
From the bar chart above, it was mentioned that a large percentage of workers in the e-waste recycling sector suffer from physical discomfort. The data indicates 52 % of respondents are experiencing physical discomfort and joint stiffness occasionally. Muscle pain/joint stiffness is also experienced by 25% of workers frequently. Furthermore, a quarter of employees stated that they often feel discomfort in their jobs, indicating that a quarter of the employees have constantly uncomfortable physical sensations connected with their work. Meanwhile, 22. 5% of the workers reported that they sometimes experience such symptoms; however, it is important to note that none of the workers interviewed answered that they never have physical discomfort. These could include; First, the recycling of e-waste involves handling dangerous chemicals, toxic metals, and other hazardous substances which may cause physical discomforts among the workers. This is often due to the nature of the job that requires repetitive movements and postures, lifting and maneuvering objects, and posture that puts a lot of stress on the muscles and joints over a while. Physical tasks such as crushing e-waste manually, dismantling, and lifting heavy loads probably cause discomfort in workers. Moreover, as it can be seen in the previous chart, workers may not

get adequate Medical check-ups and may not seek proper medical care now and then; it may mean that the signs and symptoms of their working conditions persist and turn into chronic ailments.

Several reasons may have led to inconsistencies in the level of physical suffering that the e-waste recycling workers experienced. Firstly, number one that comes out is age differences; young workers and middle-aged and old workers are different, they are much more likely to have joint stiffness and so on because the aging process is a natural process and they have been working for many more years. Secondly, the actual duties of the work, day to day-to-day activities carried out by these workers deeply influence their health. Such workers as those involved in separating constituents by crushing and hammering e-waste shall experience discomfort since the work done is repetitive, and the job requires strength. The same case applies to those who lift or move heavy materials in the course of their work and they are also prone to regular muscle and joint pains. For instance, employees who work overtime on the structural sortation or other administrative functions might declare fewer complaints of discomfort. This, following the fact that none of the respondents indicated that they have no discomfort in any way and that the physical workers handle e-waste, is clear evidence that salvaging e-waste comes with an implication for the health of the workers involved; thus, proper health checks should be put into consideration in the process.

5.4 Awareness on e-waste recycling among workers

Figure 10: Awareness on e-waste recycling among workers



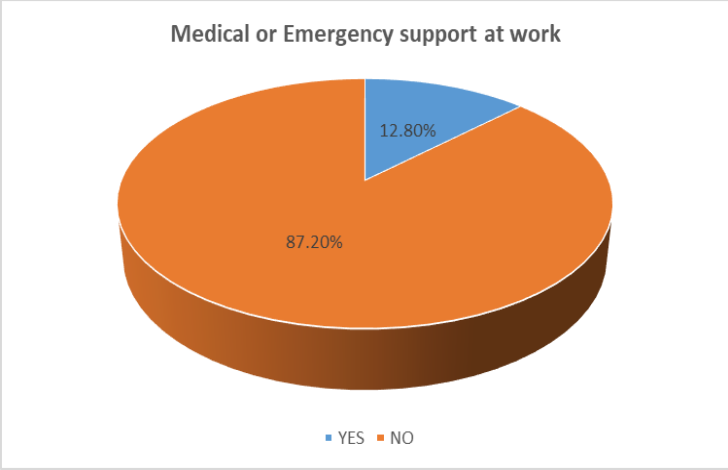
The results raise the alarm that in the recycling of e-waste, the majority of the workers are not well trained, or aware of the safety measures to be taken in handling e-waste. Among the workers surveyed: Some workers have been trained and informed on some measures regarding

safety measures. This training commonly stems from their employers, who inform them how to effectively manage potentially harming substances with e-waste recycling risks. These trained and aware individuals are 22.5%. On the contrary, 77.5% of the workers do not undergo specific training and awareness in handling the equipment. As a result, these workers are not aware of the hazardous effects likely to be occasioned by e-waste material which contains poisonous substances such as chemical ones such as lead, mercury, and cadmium. Various health aspects including skin rash, breathing complications, and the likelihood of being exposed to sharp items and machinery are still unrecognized harms for these workers.

Furthermore, some of the workers admit that they have understood certain risks but remain active in their jobs due to some reasons such as lack of money. This goes hand in hand with illustrating not only the issue of the worker's training but also other external socio-economic factors that may lead the worker to such work conditions, which may be dangerous. This shows that trained employees and untrained employees still exist highlighting the imperative to enhance the safety training program in the context of e-waste recycling. They should be offered at the workplace to make certain that all workers are availed with the information and skills needed to avoid injuries while working. Additionally, legal frameworks and the preparedness to implement them are essential in making sure that safety measures during e-waste recycling are adhered to therefore making the workplace safe for all parties by reducing the adverse consequences during the process.

5.5 Medical Support at work

Figure 11: Medical Support at work



As shown in the above graph 5 workers state that they have Medical Support or Emergency Service, which is equal to 12% of the total. On the other hand, 34 workers are not privileged to

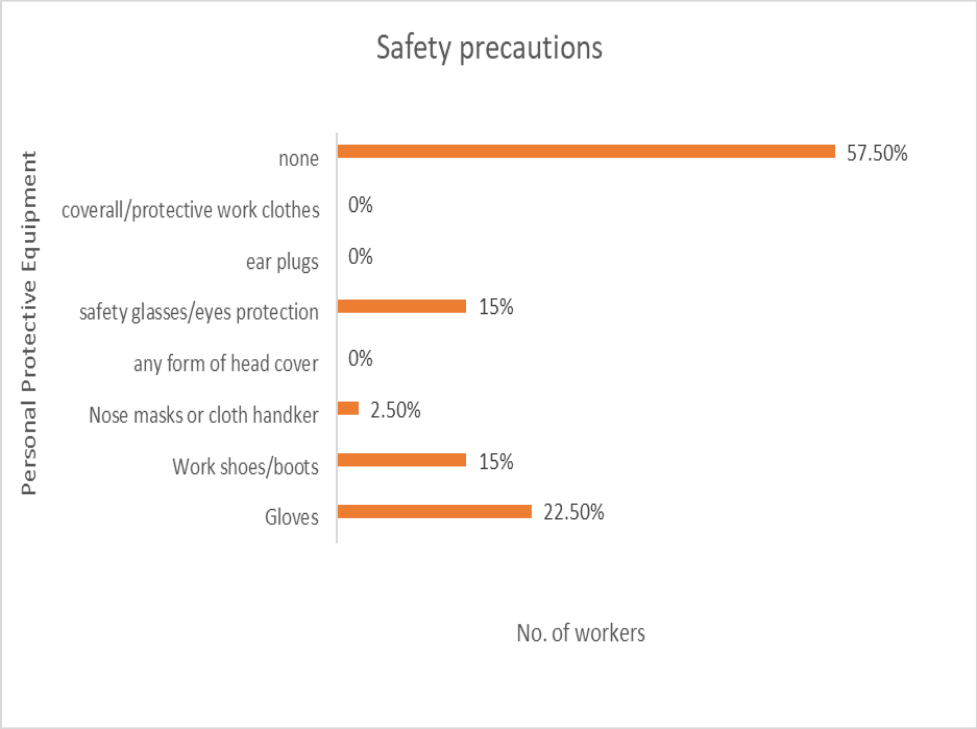
receive such support, accounting for 87%. This data shows a worrying trend in the absence of compliance with safety for employees in the e-waste recycling sector. It is very important to have access to medical help or emergency services. It is rather interesting to remark that the majority of the workers who said they have access to medical services received them through their employer, which indicates that such services are offered by recycling unit owners. This support may extend to provisions for first aid at the workplace, or paying for medical bills in the event of work-related injuries or diseases. But it is important to note that even though some employees avail of medical support from their employers, they may not get all that is needed on the side of support

In addition, many of the workers who were interviewed described a lack of availability of medical support/ emergencies in their workplaces, meaning that there is a great potential for improvement in workers' welfare for those engaged in e-waste recycling. To reduce hazards associated with this kind of job, employers and regulative bodies ought to ensure the adoption of strict health and safety standards that address such issues as medical availability. Furthermore, the availability of medical aid or an emergency service, lack of proper working tools, reasonable wages, and insufficiency of opportunities to get professional training also should be considered as significant problems of workers in the e-waste recycling industry. The wages they earn are often below a living wage and sometimes the meager wages they are paid cannot cater for their health care expenses. It is, therefore, important to address the question of low wages not only for the welfare of these workers but also to grant them access to better healthcare. However, compensation for the e-waste recycling workers and their benefits for health care and social security are critical in a strategic strategy for the protection and care of the health of these employees.

5.6 Safety Precautions

a) Use of Personal Protective Equipment

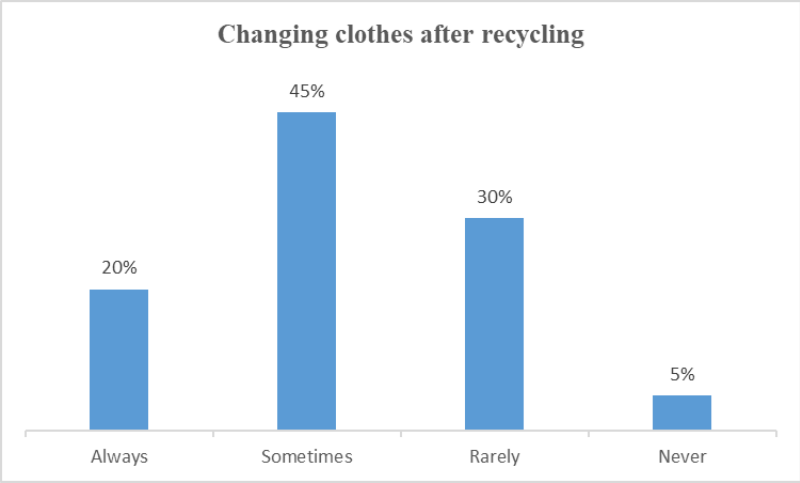
Figure 12: Use of Personal Protective Equipment



The above data in the graph provides insights into the usage of various personal protective equipment (PPE) among workers during e-waste recycling. It was observed that 9 workers only accounted for 22.5% of the total were using gloves. These 9 workers were mainly those who were involved in acid leaching etc. and these 9 workers were trained by their owners. The findings revealed that only six (15%) of the total, use special work shoes or boots to protect their feet. Only one worker of the total workers reported that they received information from the Internet as a means of self-development and only 1 worker was using the mask. No single worker mentioned using any type of headwear. 15% of the total workers mentioned that they use safety glasses or eye protection while burning harmful compounds in e-waste. About the ear protection gear, none of the workers interviewed stated that he or she uses ear plugs. The workers do not wear coveralls or protective work clothes. Lack of personal protective equipment increases the risks faced by workers in performing their tasks, which involves possible physical injuries, and respiratory complications. To avoid such risks and protect the interests of workers, the owners of recycling units must pay attention to proper equipment and its usage at workplaces.

b) Frequency of changing work clothes

Figure 13: Frequency of changing work clothes

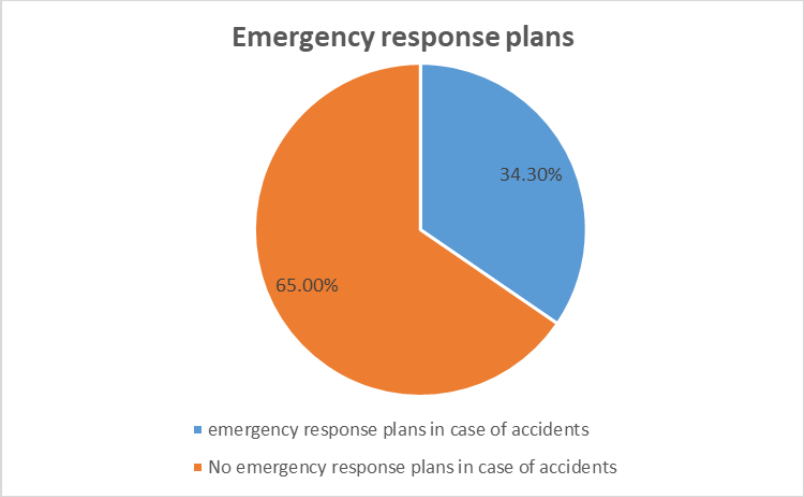


Findings depict that 20% of respondents mentioned that they always change their clothes after working on the recycling tasks, 45% of the respondents stated that they sometimes change their clothes, 30% rarely change and 5% never change their clothes. This means that a large number of workers are not in the habit of exercising the use of wearing proper apparel after their working hours, a move that poses a very big health risk to their lives. Workers who fail to take off their uniform or overall after working with e-waste get exposed to dangerous chemicals and poisonous gases that are fixed to their clothes. E-waste processing and recycling entails burning or processing of such materials in a manner that leads to the release of toxic materials such as lead, mercury, cadmium as well as brominated flame retardants. The simplest way to ingest or inhale any of these toxins is if one wears the same clothes throughout the working day and well into lunch or dinner, or even at home. Furthermore, the practice of eating in those working clothes is considered dirty due to the risk of ingestion of any particles. This poor consistency in the use of protective gear suggests that there is inadequate awareness or enforcement of appropriate attire changes to prevent worker illnesses or promote normal adherence to hygiene measures.

5.7 Work Environment:

a) Emergency response plan

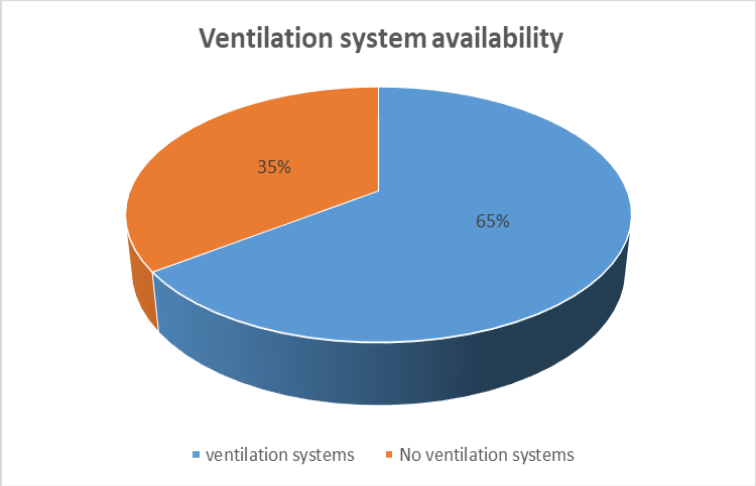
Figure 14: Emergency response plan availability



It was reported by more than one-third of workers (65%) that there was no emergency response plan in case of accidents at their recycling units. It also shows that they have not fully provided adequate preparedness of first aid measures, and mitigation measures in cases of injuries, harm, chemical spills, or fires that can greatly compromise the safety of the workers.

b) Ventilation system availability

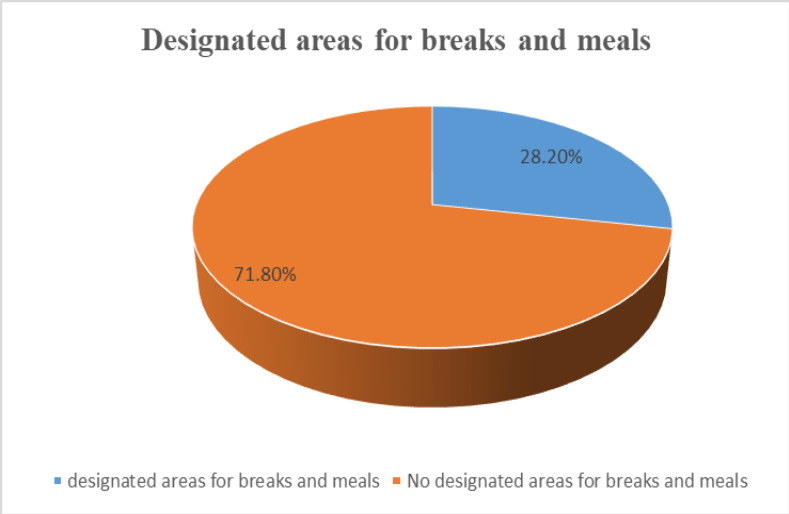
Figure 15: Ventilation system availability



As shown in the graph 35% of workers stated that there was no ventilation system at their recycling unit. This implies that there are limited measures put in place as a way of preventing exposure to toxic fumes, dust, and gases produced during the processing of e-waste that could result in respiratory illnesses and other diseases affecting the workers involved in this e-waste recycling.

c) Designated Areas for Breaks and meals

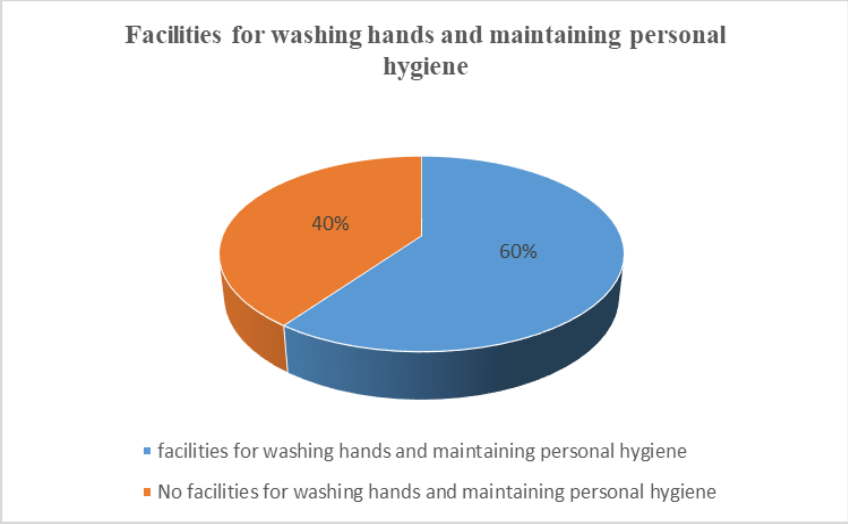
Figure 16: Designated Areas for Breaks and Meals



The overwhelming majority of workers (72%) said that the recycling units had no separate areas to have a break or meals. This would mean that there were few or few provisions for rest and having their meals. These workers have to eat and drink in the same hazardous environment, due to which they are exposed to many health hazards.

d) Facilities for washing hands and maintaining personal hygiene:

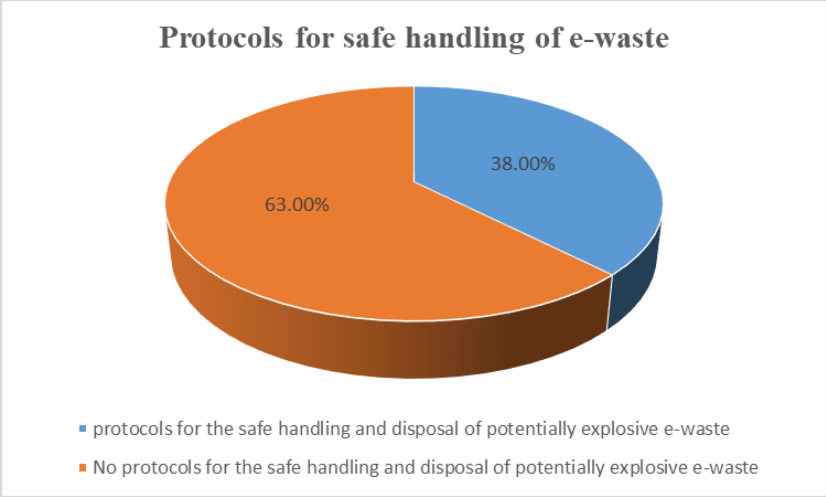
Figure 17: Facilities for washing hands and maintaining personal hygiene



As shown in the figure a considerable amount of (40%) workers indicated the absence of facilities for washing hands and maintaining personal hygiene. Poor hygiene conditions can contribute to the spread of infections and diseases among workers, posing further health risks.

e) Protocols for the safe handling and disposal of potentially explosive e-waste

Figure 18 : Protocols for the safe handling and disposal of potentially explosive e-waste



A significant majority (63%) of the workers stated that their recycling units had no guidelines for proper and safe handling and disposal of hazardous e-waste. These guidelines are instrumental in reducing the likelihood of accidents and harm resulting from handling hazardous products, which are completely disregarded here, compromising the safety of workers. The rest 37% of the workers mentioned that they had proper protocols for the safe handling and disposal of potential explosives e-waste items. While sorting they usually separate the highly explosive items according to their types like batteries etc. and then do further recycling.

5.8 Roles in E-waste Recycling

In the e-waste recycling process, a number of activities and thus related roles can be distinguished starting from collection and ending with materials' recovery. This analysis focuses on identifying important processes and their relevance to the rest of the processes in recycling.

5.8.1 Mechanical and Manual Dismantling of E-Waste

Mechanical and manual sorting is the initial phase of e-waste management, which involves the disposal of e-products into various components. Since recyclers are able to take apart items such as fridges, washers, and PCs, they are able to recover useful items like motors, metallic structures, and printed circuit boards. Disassembly makes it possible to remove valuable parts like processors, RAM chips, capacitors from circuit boards for reuse, resell or further refinement to extract the Value metals they are made of without using up much of the natural resources. This in turn reduces the overall size of waste hence its easy handling, segregation and disposal hence cutting down the overall volume of e-waste that finds its way to the landfill to a big extend thereby minimizing on the impacts to the environment. Besides, manual dismantling creates job openings, especially in

developing countries where such techniques are common to offer employment to the people to learn the ways of selecting the valuable components and putting efforts to extract them, which in return serves the country's economy. However, this has its own challenges of health risks since manual demolition is normally done by workers who may inhale hazardous substances and develop respiratory disorders or skin diseases. Hence, catering for protective equipment and training needs is pertinent.

5.8.2 Thermal Processes for Metal Recovery

Metals are reclaimed by using thermal processes mostly from wires cables and circuit boards which involves heating of e-waste with the aim of burning off all other material, leaving metals of value such as copper, gold and silver. Some of these processes include melting of copper wires, which involves burning off plastic insulation and heating circuit boards with blow torches to evaporate the plastics for the purpose of ore refining to get back pure metals. However, the emission of dangerous gases and effluents during these processes is a major cause of health concern to the employees and environmental degradation.

As a result, these methods should be carried out only in limited conditions with the necessary precautions such as proper ventilation systems and protective equipment for employees. It is also possible to increase efficiency and decrease emissions through the advancement of more sophisticated thermal recovery processes including plasma arc recycling and pyrolysis for the recovery of metals.

5.8.3 Separation and Sorting of E-Waste Components

Sorting of e-waste into different categories depending on the materials in them is an important step that defines the effectiveness of the next stages. E-waste items like computers, mobile phones, and televisions are sorted out, and their components, such as plastic, metal, and glass, are sorted appropriately to ensure they take the proper recycling stream. Batteries and CRTs (cathode ray tubes) are separated to avoid any negative impact to the environment since proper handling and disposal of these components are very sensitive due to leakage of toxic components to the environment. Proper sorting of materials promotes the efficiency of the recycling process and enhances the recycling of recyclable items. For instance, used plastic casings are taken to plastic recycling industries, and the glass from TV screens to glass recycling industries.

5.8.4 Collection and Transportation of E-Waste

Effective sortation improves the quality of the collected materials as some of them can be sold at better prices hence improving the financial position of recycling firms. Transportation and accumulation of e-waste from different sources to the recycling facilities is the initial step in the recycling process. E-waste is collected from households, businesses, and scrap yards and taken to recycling centers for sorting and further processing. Collection systems guarantee that huge amounts of e-waste are collected, which is essential for applying systematic recycling processes. Collection ensures that e-waste is not disposed of improperly by polluting the environment and guarantees that it is taken to recycling centres instead of dumping sites.

When e-waste is collected and transported systematically, it becomes easier to recycle, which serves environmental consciousness by recovering more materials for use, and can be said to contribute to the circular economy by minimizing the need for raw materials.

Mechanical methods break down electronic waste into smaller pieces. A manual process follows this, where people actually pick through the fragments to retrieve metals (mainly copper). The components are sorted; some are sent to be made into new products, while others are 'recyclable.' None of it goes into a landfill. Each one of these components is vital to ensure that e-waste is handled properly and that its diverse array of dangerous materials can be safely extracted and disposed of. To amplify the stated processes, it is necessary to take into account the difficulties they face, particularly health hazards and environmental pollution. This study highlights that technology improvement, suitable training and protecting wears for workers, and strict safety actions should be comprised to enhance efficiency and safety in e-waste management. Taking the best possible approach ensures that the e-waste recycling industry can make a massive contribution to the natural environment and promote the circular economy.

5.9 Exposure Levels in E-waste Recycling

The exposure levels in e-waste recycling include a number of dangerous situations that employees are subjected to during the different steps of e-waste recycling process. The hazards of the technological health risk pose threats to workers' safety. The most dangerous of these risks come from mechanical crushing, thermal processing, sorting, and chemical processing. Therefore, it is extremely important to develop safer technologies and ensure that effective safety measures are in place so that they may be implemented properly by workers.

5.9.1 Mechanical Crushing and Manual Dismantling

E-waste recycling cannot proceed without pre-processing, which serves two purposes: mechanical shredding and dismantling. These steps are necessary to separate usable materials from the e-waste. Employ of crusher machines and metal melting leads to high dust experience and inhalation of heavy metallic and toxic fumes during the crushing phase. Pose a threat to respiratory health cause severe respiratory illnesses lead to heavy metal toxicity put other vital organs at risk.

When e-waste is not sent to appropriate facilities for disposal, it leads to an environmental disaster. E-waste should be disposed of properly in recycling facilities that follow safe practices and are equipped with the necessary safety equipment to minimize the dangers of exposure to both toxic substances and hazardous materials found in electronic devices. Again, inadequate protective wear increases risks not just for workers who perform this kind of work but also for people who live near these dangerous disposal sites. Overall, using e-waste in local landfills or dumping it into the environment is a huge health risk.

5.9.2 Thermal Processes and Metal Extraction

High temperatures are also employed in extracting metals from e-waste, although operating under such conditions is lethal. When wires are burnt to recover copper and melting metals from the circuit boards, they release toxic gases and contaminants which are dangerous. Employees who operate furnaces, anyone who uses a blow torch to melt circuit boards, and other employees can be in contact with toxic fumes, heat, and toxins dispersed in the air. These dangerous gases present a threat to the health of people, which may lead to diseases like bronchitis, asthma, heavy metal toxicity, and respiratory illnesses.

Another kind of harm that is caused by high temperatures and pollutants in the air is skin allergies and other skin related diseases affecting man. In as much as these thermal processes are important in treatment and extraction of precious metals the question of safer procedures and adequate precaution arise. Other features such as fire seals and high efficiency air filtering are others that reduce toxicity and protect people from toxicity.

5.9.3 Sorting and Handling of E-Waste

It is a well-established fact that sorting and handling e-waste come with many chemical and physical risks. The individuals who sort the e-waste by material type including the metals, plastics and glass come across the hazardous parts. Sorting workers are vulnerable to dust and chemical hazards that can be ingested through inhalation as well as injury from sharp- edged items. The

work of sorting and separating e-waste according to their category with no protective gears puts the workers at risk of developing respiratory problems and skin diseases from handling toxic substances.

Mishandling of chemical substances during sorting exposes the workers to contract chronic breathing related complications as well as skin rash due to dust accumulation. The direct contact of the hazardous components including batteries and CRTs (cathode ray tubes) has health implications that need precautions to be taken. To avert such risks, it is crucial to advance safety measures, provide personal protective gear and conduct medical examinations on the employees undertaking preliminary segregation tasks.

5.9.4 Chemical Processing and Acid Leaching

Some of the most dangerous tasks in e-waste recycling include chemical processing and especially acid leaching roles. Circuit installation also poses several risks including electric shocks, toxic gases and corrosive chemicals when electricians working on circuits use acids to dissolve metals to connect electronic parts. This exposure might result to serious cases of chemical injuries, respiratory illness and other illnesses that emanate from the fumes of the chemicals in use as well as direct contact with the chemicals. Substances such as hydrochloric acid and sulfuric acid can be hazardous and therefore it is important that safety measures be put in place so as to avoid a situation where the workers are affected.

Some of the health risks that workers experience when involved in processes such as using solvents or heat to extract materials include the following;The processes that utilize solvents and acids require proper flow of air, protective clothing and constant training because these processes are very poisonous. These measures should be followed to prevent diseases and safeguard the health of the employees undertaking such crucial though risky tasks.

Summarizing, exposure levels in e-waste recycling show that there are many severe health hazards workers can be exposed to at different stages of the recycling process. From mechanical crushing accompanied by manual dismantling to thermal treatments and chemical processing, each stage is associated with certain risks that need special safety measures and innovative technologies to minimize threats to workers' health. Reducing health risks can be achieved by using better technologies, properly training operatives, and providing protection gear. Safe practices that are as effective as they are safe can enhance the sustainability of e-waste recycling and the circular

economy. E-waste contains toxic materials like lead, mercury, and cadmium that can be harmful if not handled properly during recycling processes.

5.10 Health Status Prior to Joining E-waste Recycling

The workers in the e-waste recycling industry have varying health conditions before they start working. Some claim to have had good health, while others report some health issues even before they began working with hazardous materials like the kinds found in electronics. We can group our respondents into two categories: those who mentioned they were in good physical form before starting to work and those who pointed out some health issues they had when they got the job.

5.10.1 Majority in Good Health Prior to Joining

Many people who work in e-waste recycling say they were healthy when they started the job. They stressed that they rarely suffered from any serious ailments, diseases or health complications before engaging in the profession. Phrases like 'I have never been ailing from any sickness at all before engaging myself in this profession' show that at one point, a large number of workers were actually in good health when they started practicing e-waste recycling.

This means that if workers are healthy when they join a certain workplace, then any illness they may develop can largely be attributed to exposures at the workplace. The change from good health to possible health issues after one is employed promotes the fact that e-waste recycling comes with risks. Prolonged working exposure to toxic chemicals, electronic dismantling particulate inhalation and manual job positions exert pressure and affect the general health of the employees.

Perceiving the first health condition of workers addresses the necessity for health and safety prevention at the workplace. They include frequent medical check-up to detect signs of the diseases early, modifications of the workplace and equipment design to minimize employees' physical stress, and effective orientation on how to deal with toxic substances which are likely to affect the health of the employees.

5.10.2 Minor Pre-existing Health Conditions

However, only some of the workers interviewed revealed that they had had minor health complaints before engaging in e-waste recycling. All these ailments including arthritis, joint pains, back pains, asthma, and stomach problems were more or less intermittent and did not limit their working capacity considerably. It is documented that some workers reported such things as "mild joint pains and asthma" or "body aches after exercising," which meant that these problems existed but did not significantly impact their functioning.

These harsh circumstances, typical of e-waste recycling environments, can cause aggravation of comparatively minor existing health issues. Conditions such as joint pains and respiratory diseases can be worsened by repetitive bending and lifting, dust particles containing toxic chemicals, and working for extended hours in harsh conditions. Although these conditions were initially controllable, constant exposure of workers to these occupational risks causes chronic development of health complications. This reaffirms the need for constant health check-ups on employees and adjusting measures to prevent the worsening of health amongst the workforce.

Employers have the responsibility of ensuring that they transform working environments in a way that will reduce an employee's health risks especially those with diseases. It is useful to manage existing health issues through ergonomic changes in work organization, providing suitable personal protective equipment (PPE), and offering periodical medical checkups.

A consideration of the health status of the workers before engaging in e-waste recycling shows the relationships between pre-existing health and employment health hazards. Although most of them indicated that they joined the profession in very good health, the possible effects of some workplace exposures cannot be overemphasized hence the need for enhanced protecting health measures at workplace. Hazard control, ergonomic improvements, and constant health checks are some of the measures that should be taken before dangerous experiences happen to people involved in e-waste recycling as long-term measures to create safe working conditions for employees.

5.11 Health Deterioration Among Workers After Joining E-Waste Recycling

Recycling e-waste creates health risks for the employees in the industry due to several health conditions experienced by the workers. This analysis focuses on these effects: broad health understanding; physical and mental pressure; respiratory issues; and eye diseases/skin sensitivity among workers.

5.11.1 Perception of No Health Impact

A significant number of workers involved in e-waste recycling refutes adverse health impacts of their work practice. They state that they have not experienced any changes in their health since they joined their respective fields which suggests that they are overall content with their workplaces. The following statements are examples of such positive attitude: 'No, I do not observe any health issues; my health remains the same." Although these perceptions offer a snapshot view of how workers, for instance, are experiencing their heath, it fails to give an objective picture of

how their heath is gradually deteriorating over time as a result of hazards. Self-rating of health reflects the workers' emotions on their health but does not consider future ramifications. The next process is that of objective health monitoring, which includes periodic examinations for signs of health problems that the workers themselves may not immediately sense; this way, it is possible to avoid the development of these problems.

5.11.2 Physical and Mental Stress

On the other hand, studies reveal that many employees experience increased physical and psychological demands due to their occupations in e-waste recycling. Symptoms like fatigue, stress, sleep disturbances and headaches are always evident since the workers are exposed to fumes, noise and physical stress while performing these tasks. These occupational stressors significantly affect the health of workers, thus calling for measures to address these issues.

Thus, understanding that workers are under physical and mental pressure, it is necessary to increase the ergonomics of workplace and working activities. Furthermore, stress management and counseling services are important to make the workers to be in a position to handle the stress that comes with their working conditions.

5.11.3 Respiratory Issues

Yet another health problem that e-waste recycling workers are exposed to is respiratory diseases. This happens mainly because of the dust, fumes, and other particles that float in the air while people work with electronic waste. Some serious side effects can occur from breathing all those harmless-sounding things. For instance, worker complaints include a persistent cough, shortness of breath, and colds.

People are more likely to develop respiratory illnesses like bronchitis and asthma if they are exposed to hazardous particles long before those illnesses show up as diagnosed conditions. Controlling risks means doing many things well—an owner has to manage rightly what is an improper airing system, in addition to having respiratory protection available and easily usable for employees who need it.

5.11.4 Eye Infections and Skin Allergies

People who work with e-waste have their eyes at risk from infection. That's because the dust kicked up when parts are scrapped contains lead and other toxins that can cause eye Agent Black Lung, a condition that makes the eyeballs grow into hydrocephalic cysts. The poor lighting makes it hard

to see what you're doing. If you handle poisonous materials as this job requires, you're also at risk for skin allergies and very uncomfortable working conditions.

To prevent the development of such complications and injuries, eye protection gear must be provided and the correct lighting conditions must be ensured. Practice high levels of hygiene, and make sure you are using appropriate personal protective equipment (PPE) to minimize skin exposure to agents that can cause problems.

The e-waste recycling industry has a significant workforce requiring commensurate health effects, and those have not been sufficiently noted. Appropriate measures of health and safety could correct this situation. Workers in the e-waste industry are put at risk for a variety of serious health hazards—one of the most significant being mental stress. That can lead to respiratory problems; eye infections, skin allergies, and other physical conditions can develop as well, especially if appropriate workplace safety measures are not in place. Even taking care to observe all reasonable safety rules will help maintain production as a durable mechanism for sustaining an e-waste recycling industry.

The e-waste recycling industry has a number of health issues associated with it. These necessitate doing whatever we can to create a safe and healthy work environment. We must prioritize asymptotic safety, which is the whole kind of ambience that keeps illnesses from happening. Preventing an illness from taking hold is as it should always be the gratitude that can do so are compulsory; preventing eye infections and stress breathing circumstances means that protocols and procedures must never be forgotten. When sustainable waste management practices are followed, we create a space where cultures that marginalize particular illnesses can exist in ways that also push toward the enactment of another category: responsible management.

5.12 Medical Visits and Health Care Access in E-waste Recycling

5.12.1 Frequent Medical Visits Due to Job-Related Health Issues

Work in the e-waste recycling sector demands multiple doctors' visits because of the health risks involved. Recyclers are exposed to hazardous chemicals and physical conditions that make them liable to a variety of diseases and injuries. Such working conditions render these individuals more unable to secure life cover — through health insurance, for example — although they must rely on healthcare services for some sort of coverage as their lives plod along in this poor health chain.

5.12.2 Routine Medical Check-Ups for Chronic Conditions

Even workers involved in e-waste recycling have their health checked every 3 months. They do this because many illnesses are associated with working in such a hazardous environment, and the chronic ones need close monitoring to prevent them from becoming worse. These periodic checkups help treatment not only rise to the level needed to make the worker whole but also help employers understand how badly their employees are at risk for work-related illnesses – an important point that really helps speed up improvements in workplace safety and health. To extend these efforts, employers should provide flexibility to accommodate employees with chronic diseases and provide access to medical means.

It is crucial to involve healthcare workers and occupational health professionals to organize unique health management systems providing long-term health support for patients and contributing to the improvement of workplace accessibility.

5.12.3 Limited Office Visits Depending on the Symptoms

Some workers exposed to e-waste recycling regularly see a doctor when health conditions dictate, not by schedule. They take care of their health on their own and only go to see a doctor when the condition becomes unbearable. It may be construed as a rational way of selecting a health care provider while taking into account pragmatic factors including time and other obligations. It is therefore important to educate such workers on early symptoms of most illnesses and self-care interventions to improve their capacity to take appropriate decisions on seeking treatment. Promoting symptom recognition and knowledge of best measures to adopt in order not to worsen one's health should also form part of workplace health programs.

5.12.4 Limited Health Care Access

Among workers in e-waste recycling, many cannot afford to seek medical treatment often and only consult doctors when their conditions worsen. This points to the fact that economic status plays a crucial role in determining health status, as poor individuals cannot afford to seek proper treatment for conditions that affect their ability to work. These barriers are best tackled where employers and policymakers need to seek remedies such as employer-subsidized medical care, health insurance for employees, and work health funds for those who require medical attention. One can prevent the effect of budget constraints on health of the workforce and standardize overall healthcare by encouraging the use of preventive measures and early screening of workers' health.

The frequency and nature of medical visits therefore depict various health issues and utilization that are shaped by the working conditions of e-waste recycling workers and their socio-economic status. The e-waste recycling industry is not an ideal place for promoting public health. This research found that recommending healthy lifestyle changes to workers in this industry is almost like telling someone to exercise and eat well while they are incarcerated. The e-waste recycling process itself presents many health risks—from the long lists of hazardous chemicals involved to the hazard of workers' physical and mental health—and those dangers are compounded when you consider how little care that has often been taken in designing products or controlling the conditions of work.

5.13 Health Hazards and Working Conditions in E-Waste Recycling

5.13.1 Toxic Fumes and Health Hazards in E-Waste Recycling

There are many hazards associated with e-waste, but one of the most serious is noxious gas. People who work with electronics dispose of their materials under dangerous conditions because there is so much money to be made from what we consider to be garbage. When people work with electronic components obtained from devices that have been taken apart and sent to them for refurbishment or recycling, they are frequently exposed to toxic substances. There is no way to stop or prevent the intense number of contaminants released during the process, and because they are mixed with ambient air, they become unhealthy gases for anyone near them who isn't protected against what's happening.

5.13.2 Health Issues and Environmental Concerns in E-Waste Recycling

Taking apart electronic waste is hazardous. It releases many dangerous dust particles and chemicals into the air, which makes the inside of e-waste recycling facilities a place where workers can develop serious respiratory conditions—and may already be suffering from poor air quality. Skin problems are another price that e-waste workers pay. And it's not just immediate contaminants that pose long-term health risks; E-waste itself is a well-known carcinogen and contains other long-lasting toxins—a suite of hazardous materials we've come to call 'electronic waste.' Still, it is impossible to avoid talking about these risks and their potential consequences if we are to understand what e-waste recycling looks like from inside the ecosphere. The byproducts of recycling—particularly certain metals, such as lead, mercury, and cadmium—can be very dangerous if the workers who handle them aren't properly protected or if those hazardous materials aren't contained.

5.13.3 Stressful and Tiring Working Conditions in E-Waste Recycling

Exposure of workers to e-waste and their work conditions causes serious health problems. The Health Risks from Informal Electronic Waste Recycling are Real. In the 'e-waste dump,' there is a lot of dust, which causes respiratory illnesses and poor environmental conditions in the workshops where people dismantle computers, televisions, and other electronic devices. Many adverse health effects can happen to the workers who do the dangerous and close work of cleaning up these products — mainly because the products contain many toxic materials that were not hazard-free even when the items were marketed as 'electrical electronics'. Such occupational health risks make a significant impact on individual employee's health as well as the environment by polluting it and making it toxic. Appropriate steps could be taken to address the issue of air quality control, safety measures, and ensuring adequate health safeguards to reduce the negative impacts of health and environment of e-waste recycling industries.

5.13.4 Explicit Denial or Lack of Awareness of Correlation

The writing conditions in e-waste recycling are describe as highly stressful and physically demanding and presents and presents major challenge to the health of the workers. The tasks performed include dismantling, crushing and sorting of electronic waste hence the workers are always with body aches and body strength is always strained. These activities require manual dexterity, demand long hours of work that expose the workers to unfavourable working conditions that lead to fatigue and stress.

Manning risk assessments, implementing improvements in safety measures, and offering health interventions, stakeholders can create a secure environment for all involved workers and recycle e-waste safely. Promoting the health of workers goes hand in hand with both individual well-being as well as supporting healthy and sustainable business models and health equity for society in the e-waste recycling industry.

5.14 Awareness of Potential Hazards in E-Waste Recycling

The e-waste recycling industry carries numerous risks for those involved in it. This research aims at looking at the various levels of awareness that are there regarding the various risks affecting the workers' health, the various levels of awareness include a good level of health risks awareness, moderate level of health risks awareness, poor level of health risks awareness, and a very poor level of health risks awareness.

5.14.1 Awareness of Specific Health Hazards

The risk perception of these workers regarding the direct health risks associated with e-waste recycling is relatively high. These people have comprehensive information on hazardous substances like lead, mercury, and cadmium that are contained in used electronics. They are well aware of how these substances affect them directly having suffered from respiratory problems, skin irritation, and inflamed eyes resulting from contact with toxic fumes and gases. This awareness is premised on firsthand acquaintance with health challenges linkable squarely to their workplace. For example, they may narrate cases that show how they contracted sicknesses, acute or chronic as a result of handling dangerous substances. This theme emphasizes the perceptions and awareness that are created by workers gaining close experience of their working environment. It also emphasizes the necessity of properly addressing the problem of orientation and training in health among the workers to equip them with knowledge that would enable them to shield themselves adequately.

5.14.2 General Awareness of Harm but Lack of Detailed Knowledge

Yet another group of workers is aware at least to some extent that e-waste recycling is dangerous to health but lacks detailed information about the kinds of danger. These people know the risks involved in the working environment including cuts by the sharp edges or even the dangerous nature of the job. Thus, their awareness could be restricted to such things as the immediate physical danger of using products containing toxic substances such as heavy metals and chemicals. This lack of detailed knowledge has led to a lack of education and training pertinent to the various health risks and their potential consequences. Workers in this collective category require special training to have total knowledge about hazardous substances found in electronic waste and the negative effects they can have. This knowledge enables them to act as the first line of defense in identifying and preventing any potential hazards that may arise on the job.

5.14.3 Lack of Awareness

Many workers in the e-waste recycling industry have no idea that the materials they're working with are hazardous. That people who do dangerous work aren't even aware. The reason for this appalling ignorance lies mostly in whom you ask and how they see the situation. Viewing it from the perspective of an uninformed worker allows us to better understand why so many workers steamroll into danger with so little knowledge about what they're doing or what's at risk—hearing about it only after something has gone wrong.

The failure to recognize potential hazards could result in workers being exposed unintentionally and improperly to dangerous substances. That can happen when the public, even meticulously following reasonable safety precautions, can still be put at risk by hazardous materials while those substances are being produced or used. It is important that workers receive adequate training as well as a clear understanding of the nature of the risks involved so that they might better protect themselves after being given inadequate information by management.

5.14.4 Awareness Coupled with Acceptance or Resignation

Some workers have knowledge of the health hazards associated with e-waste recycling, but they see those dangers as unavoidable if they want to keep their jobs. These workers can be forced to work against their will if they wish to make ends meet due to economic pressures. They agree with these points but explain that things are limited by financial considerations or lack of other jobs. This acceptance or resignation points to excellence or compromise between economic drivers and health concerns in career choices. Indeed, these workers may be aware of these risks but are limited by factors outside their control in dealing with the risks effectively. To resolve this problem, structural interventions will hence have to be implemented with the aim of enhancing the welfare of the workers such as by enhancing work conditions, and providing alternative employment sources, wages, and so on. By dealing with the matters that lead to workers' decisions, which are economic in nature, stakeholders can ensure that health and safety at the workplace are not geared to be traded upon for financial sustenance.

The variation in the level of awareness on health risks among the workers in e-waste recycling bring out the multiplicity of occupational health and safety issues. Thus, ranging from IA of certain risks to no awareness of them at all or even acceptance of all kinds of risks, each viewpoint outlines different possibilities of enhancing the situation. Thus, the improvement of education, training, and communication about the existing health risks are the critical steps to helping workers avoid potential dangers. Besides, economic incentives and safer working conditions are essential to make the e-waste recycling centers safer and healthier ones. When awareness and action become priorities, then stakeholders can create an environment that ensures safety and well-being of the worker, the company, and the society.

5.15 Recycling Methods in E-Waste Recycling

There are several ways that the e-waste recycling industry sorts and separates electronic waste in order to extract useful materials, which all possess certain consequences for the resource supply, employee exposure, and the environment.

5.15.1 Comprehensive Sorting and Separation Processes

The main steps, which remain at the core of e-waste recycling, include sorting and separation for possible recovery of copper, gold, and silver, as well as to eliminate adverse effects of lead and mercury. These processes include the use of intricate equipment like crushers, burning for sorting and recovery, and complex processes like the use of acids and magnets.

Through proper sorting of e-waste, the recycling firms ensure that they get the most amount of material which should be recycled out of several material streams. This helps in getting away from virgin resources, which is good for sustainable management and utilization of resources. The first step in waste disposal practice also reduces environmental pollution and adverse health effects on people who come into contact with such waste. Due to the risks that most of the materials pose to the workers handling them, safety measures must be adequately followed.

Extraordinary measures and precautions must be taken to ensure that employees are shielded from risks involved in managing e-waste such as exposure to toxic substances and physical dangers. Recycling plays a big role in environmental management as it encourages the decrease of landfill site usage and energy utilized in the extraction of raw materials.

5.15.2 Burning and Melting for Material Extraction

Melting and burning processes are used to get rich metals like copper out from sections like the wires and the motherboards of the e-waste. Although these techniques can be used to extract materials from a waste stream, the process is still hazardous because it emits noxious fumes and gases. Pyro metallurgical processes that involve burning and melting are particularly important in the recovery of metals from the intricate electronic components making up e-waste since they aim at achieving the highest yields and monetary value from the recycling of the wastes.

Since the burning and melting of the material leads to the release of toxic fumes, it becomes quite important to ensure that there is proper ventilation and that these fumes do not pollute the environment or harm the workers. To address these risks, organizations need to adhere with the regulatory requirements.

Compliance with environmental laws protects the employees and the environment through limiting the emission of ash and toxic gases during burning and melting steps in the e-waste recycling facilities.

5.15.3 Crushing and Shredding for Reusable Parts

The first steps in e-waste recycling are crushing and shredding, which are important mechanical operations that are used to disassemble electronic devices and produce a large number of tiny particles that can be easily sorted by components in the following stages. Comminution or size reduction enhances the functionality of e-waste by making it easier to sort and preprocess before optimal material separation like magnetic or density techniques. This makes the process of separation more effective and gets a higher quality of the material that is to be resold or recycled. It is important to monitor and maintain the crushing and shredding equipment as well as provide sufficient training to the operators in order to minimize any risks that are associated with mechanical processing and improve the overall workplace safety. The way in which materials are shredded is essential toward ensuring maximum recovery and purity and reducing impurities to levels which make them useless in secondary markets or manufacturing.

5.15.4 Manual Dismantling and Sorting

There are many crucial stages in the process when electronic devices are dismantled and sorted by hand where workers separate useful parts and components and sort different materials by their type like plastics, metals, and glass. Manual dismantling allows for better preservation of high values components and is proven to result in higher rates of material recovery and therefore, more significant economic returns from the e-waste recycling business. Besides, the work of qualified personnel is crucial for the correct sorting and dismantling of waste, which proves the significance of professional training and experience when improving the effectiveness of recycling activities and achieving the highest possible percentage of resource utilization.

5.15.5 Varied Recycling Methods and Adaptability

Adequate work conditions, and protective gear for workers are a major factor in preventing and minimizing health risks during manual handling of the e-waste components. Moreover, while presenting the general process of e-waste recycling, it is vital to note that various methods are used to cope with different types of electronic waste and the materials they contain. The flexibility to adjust recycling processes for recurrent day-to-day business requirements and material properties optimizes collection and e-waste recycling centers.

Conducting a constant assessment and enhancement of different recycling methods encourages technological advancement and efficiency in matters concerning waste electrical and electronic equipment management for sustainability and cost-effectiveness. Comprehensive training programs enables workers to be productive and safe in using a variety of recycling approaches that are required in the organization's daily operations.

The different processes that are used in the recycling of e-waste also show that the e-waste recycling business is diverse, and it is crucial to achieve an optimal combination of material recovery, using safe labor, and minimizing the negative impact on the environment. Appropriate sorting and separation techniques, the minimization of dangers related to burning or melting, the improvement of mechanical processing in the form of crushing or shredding, and the proper use of careful hands-on disassembly and sorting can make the process of e-waste management safer and more sustainable for stakeholders. High-quality training, combined with continuous improvement and compliance with relevant regulations must be employed for a sustainable positive change and a circular economy where electrical waste is managed correctly, and valuable resources are not wasted.

5.16 Disposal Procedures for Waste Generated in E-Waste Recycling

Waste Disposal is another important aspect of the e-waste recycling industry and has a direct relation to the environment and the workers. The following study looks at the different disposal procedures mentioned by the workers of e-waste recycling plants and their analysis.

5.16.1 Burning and Incineration of Leftover Waste

Dunking and incineration are often painted as common ways whereby industry disposes of the residual e-waste. This encompasses using fires to melt wires and other parts to recover metals, burning Non-Ferrous materials, and, at times, open burning. To many a worker, burning is used as a way of decreasing on the amount of waste as well as conserving on the metals. Nevertheless, this method is dangerous to human health and the environment because it generates toxic gases and fumes. Burning is done by workers in open space or in substandard structures that have inadequate facilities for the control of the emissions.

Incineration of e-waste can help recover metals but comes with a number of issues including production of dangerous gaseous pollutants such as dioxins, furans and heavy metals. Such pollutants present a lot of health hazards to the workers and the residents around the industries. It is critical that the burning of e-waste must respect environmental laws to reduce the amount of

toxins released into the air and to protect the workers. The following risks arise from environmental pollution: Failure in adhering to emission control standards and failing in handling of wastes are some of the risks that are associated with environmental pollution.

Employees exposed to burning activities are most exposed to adverse health effects common to toxic fumes and gases likely to cause respiratory illnesses, skin disorder, and long-term conditions. This common safety measure entails proper installation of the ventilation systems and ensuring that the workers have the right PPE.

5.16.2 Dumping in Landfills and Open Spaces

Another way stated by the workers of managing e-waste is dumping it in landfills, open spaces or merely throwing it because appropriate disposal facilities for e-waste are not easily accessible. This is where people dispose of waste by either throwing it in the ground or putting it in an area that is to be picked up by garbage trucks. Although it is a practical solution for waste disposal for some time, it has a lot of detrimental consequences affecting the environment and health of living organisms. Dumping e-waste in landfills poses dangers of leaching of chemicals including lead, mercury, and brominated flame retardants to the soil, water and nearby habitats. Such materials have long-term detrimental effects on the quality of the environment and sustainability of life.

Disposal of wastes, especially hazardous wastes, has to meet the requirements provided for in the local laws on landfilling. Successful contamination control and compliance with the law requires the appropriate selection of the site and containment methods and assessment of compliance with the legislation. Disposing e-waste in ease creates health risks to the surrounding communities in regard to leaching of contaminants and direct exposure to toxic compounds. Practical methods in handling wastes are paramount to safeguard the health of the people as well as the condition of the environment.

5.16.3 Collection and Transport to Designated Disposal Sites

It's safer to collect leftover e-waste and have it transported to disposal sites or dumping areas that are regulated. This is what workers who do the dangerous work of disposing of electronic waste say happened to them, and it's understandable that we might not want to think about the risks they took while doing that close-to-hazardous work. Ensuring that waste is transported to the correct disposal locations allows for adherence to strict local waste management regulations. No risk exists that the environment will be contaminated by improperly managed waste because exposure risks

are minimized during transportation, and all hazardous materials are handled in accordance with established procedures.

Using designated disposal sites allows for correct waste separation, not to mention a means to recycle or treat waste properly under environmental standards. It's really the only way to ensure anything close to an "eco-friendly" outcome for e-waste recycling operations. Having set schedules and well-organized disposal processes makes waste management run much smoother; it allows for better usage of time and makes it more difficult for waste to be disposed of illicitly or in an environmentally hazardous manner.

5.16.4 Organized Storage and Collection Processes

The work of sorting, categorizing, and storing waste electronic materials is vitally important if we are to move toward a closed-loop recycling process that helps keep toxic materials out of landfills while also providing minerals for the kinds of devices we use. E-waste recycling facilities across the United States are doing some type of manual work in this area despite being equipped with conveyor belts and pick pockets; unfortunately, they are still largely relying on poorly paid labor to sort through massive amounts of electronic waste.

Storing and organizing various kinds of electronic waste makes it possible to separate different elements for recycling and proper disposal. This enables the recovery of many materials—like copper, steel, and plastics—that would otherwise go to a landfill. It is of the utmost importance that things are sorted, put away in their proper places, and not permitted to accumulate in large quantities. There should be designated areas for these practices and supplies needed to ensure a safe and efficient work environment. Providing suitable training, PPE, and ergonomic facilities supports worker health and decreases the risk of injuries or experience to hazardous materials.

The disposal methods for the waste produced in e-waste recycling range from ordinary incineration and landfills to a well-organized collection and transport system that leads to environmentally sound disposal sites. There are four methods used worldwide: burning, which is unhealthy and emits greenhouse gases; landfills, where electronics can release dangerous chemicals when the contained materials are buried and subjected to heat; proper incineration under conditions that allow for the capture of hazardous emissions; or disposing of e-wastes at outdated technologies that are mined for their recoverable materials—a method known as "urban mining." An effective and concerted e-waste recycling industry could achieve the necessary makeover for safer, more

sustainable disposal practices to address current challenges. That starts with prioritizing some basic environmental safeguards—something this industry has been bad at so far.

5.17 Improving Health and Safety Conditions in E-Waste Recycling

It is vital to Improve health and safety conditions in the e-waste recycling industry to protect workers' welfare, enhancing job satisfaction, and promoting supportable practices. This analysis discovers key policies reported by workers to improve safety, expand working conditions, and support health care desires in e-waste recycling facilities.

5.17.1 Enhanced Safety Gear and Training

The workers who carry out this e-waste recycling emphasize the need to put on the right protective clothing in order to be safe for handling the dangerous product. Personal protective equipment including helmets, jackets, trousers, goggles, face shields, and masks are effective methods of preventing exposure to toxic fumes and chemicals found in e-waste. Besides, extensive programs provide the worker with knowledge on the right methods to use, safety measures to consider, and other precaution measures to adhere to in case of an eventuality.

Effective safety measures also lower risks of accidents at the workplace and prevent health complications due to contact with hazardous elements like lead, mercury, and brominated flame retardants, among others, in e-waste. Providing safety equipment and knowledge to the workers helps to give the workers ability to perform their tasks securely, which is beneficial to creating a safer work environment. They are articulated to ensure that employers adhere to the legal requirements in the provision of protection of employees against workplace risks. Constant staff training and security procedure refreshers are crucial for ensuring continued compliance and improvement in safety attitudes.

5.17.2 Satisfaction with Current Work Conditions

Although the nature of work in e-waste related industries has many drawbacks it is important to note that a portion of workers remains satisfied with existing working conditions. It is an important source of income for many people as they use the money they get from here to support their families. This job satisfaction is likely to originate from the security of a job and financial obligations rather than the actual job content.

Reuse or recycling of e-waste also helps employment of workers and their families because there are few other opportunities to make a living in such areas. Various studies show that job satisfaction is the measure of the economic aspect of the job and the inherent difficulty involved

in the disposal of e-waste. Measures toward improving the working conditions should therefore ensure that this stability is kept while at the same time improving on safety and remuneration. Indeed, the level of satisfaction with current working environments is reasonably high, but there are still definite ways to improve job quality, including safety standards, the conditions themselves, and support services.

5.17.3 Improved Working Conditions

Employees demand better living conditions during working hours whereby the environment is clean, free from clutter, with good ventilation and other necessities including clean water for drinking and washing among other necessities. Regular cleaning and writing organizational practices lead to organizational morale, and improved health among the workers due to the minimized exposure to health hazards. High levels of workplace cleanliness and orderliness are associated with improved human health, reduced rates of employee sickness and technology recycling e-waste, and enhanced productivity among workers who come into contact with recycled e-waste. Ensuring that there are enough amenities and reducing working hours which will in turn decrease stress levels and fatigue hence create a good atmosphere at work and increase satisfaction. As defined by this research, sustainable working conditions mean environmental responsibility involving activities that minimize environmental impacts and enhance long-term sustainability of e-waste recycling businesses. There are fears on who will provide and accommodate their health care services, first aid, and financial supports in case of any work-related injuries or health complications in e-waste recycling.

5.17.4 Healthcare Support and Compensation

Thus, the article emphasizes adequate budgeting for healthcare and insurance supports in light of possible adverse health effects of handling dangerous substances. Ensuring medical treatment and payment is a clear sign of employers' concern and readiness to take care of their workers while working in e-waste sector. Timely medical aid and sound remunerations for injuries or diseases incurred when working ensure that the costs and health risks are well managed, translating to workforce retention and positive attitudes.

Advising and implementing compliance with labor laws and regulations involving health care benefits as well as compensation is crucial in safeguarding the rights of the workers and their fair treatment in the workplace. The goal for increasing the health and safety standards of e-waste recycling thus has four major components: the better health protection equipment and education,

promotion of personnel satisfaction and economic security, improving working conditions, and effective medical assistance and compensation. These concerns have led to the following crucial areas to address in order to have safer and sustainable workplaces that enhance the well-being of workers as well as the environment in the disposal of electronic waste. These goals can only be achieved through interacting with the workers, obeying the legislation rules, and investing in infrastructure and training Organizing invents e-waste recycling business at the ethical way.

5.18 Discussions

Electronic garbage (e-waste) is both harmful and incredibly useful. Recycling e-waste is critical for lowering the environmental effect of producing these items since it allows for the recovery of valuable minerals and rare precious metals. E-waste is collected and dismantled, with different parts of it sold to a variety of stakeholders, including metal extractors and recycling units. In Shersha Karachi, there are so many workers from age 10 to 55, even whole families involved in e-waste recycling mainly in extracting silver, copper, steel, and brass from even the smallest cables and different chips and selling it per gram. The working conditions are rough; there are very few tools and no health protection. The workers work without masks, glasses, or gloves, surrounded by sickening smells. The waste produces smoke containing harmful dioxide and monoxide carbonate. Inhaling this smoke can be extremely toxic for the lungs and the brain. The workers involved lack education and are not fully aware of the health and environmental risks, treating it solely as a business matter. They handle these toxic materials without understanding the potential consequences.

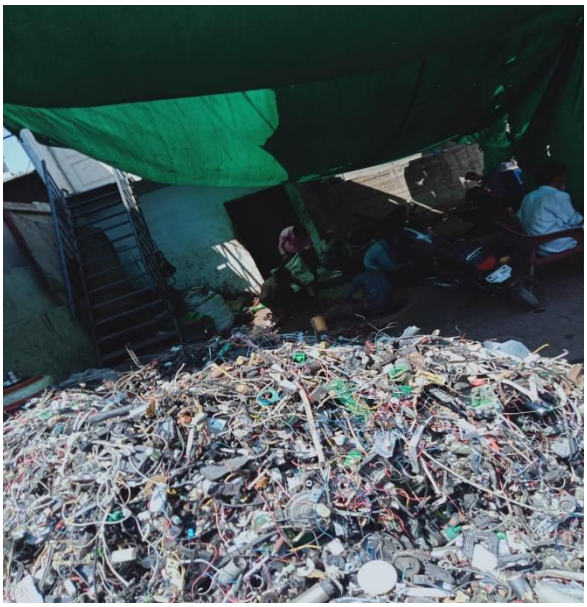
In Shersha, the entire community is at risk of getting affected by the poisoning caused by electronic waste. Substances like lead, cadmium, and mercury are gradually polluting the neighborhood, leading to widespread illness even among those who do not work directly with the waste. Surprisingly, no one appears to be concerned about this alarming situation. Electronic waste and its toxic substances are situated in each household because whole families are involved in e-waste recycling, exposing the entire family to them. Unfortunately, taking precautions is considered a luxury in Shersha, as it is widely known that individuals who start working in recycling tend to lose ten years of their lives. The effect of electronic waste is not only limited to the workers and their families' health; it also poses a significant threat to the environment. Shersha stands as one of the most polluted neighborhoods in Pakistan, with contaminated groundwater and the burning of toxic residues within the landfill. This poison seeps slowly into the water and soil,

causing further harm. The leftover waste after recycling is either openly burned or dumped which is very harmful to the whole ecosystem. The health of the people is affected since burning or dumping waste releases toxic chemicals, which when inhaled, ingested, or come into contact with the skin for a long time can lead to cancer, skin allergies, respiratory disorders as well as other illnesses. As a result, appropriate measures for the disposal of waste should be taken effectively to ensure that the health and the environment are not affected.

The material extracted from informal e-waste recycling in Pakistan and other countries is often sent back to developed nations for reuse. This creates a cycle where the materials removed from this e-waste which includes different chips, cards, etc. are not currently useful to Pakistan, but they hold great value for countries like China and Europe. Plastics, gold, silver, copper, and aluminum are among the most popular materials. Wire burning for copper, toner sweeping for aluminum, and acid dipping and burning printed wire boards to recover precious metals are all examples of informal recycling procedures. These processes emit hazardous compounds, such as dioxins and furans from burning plastic, into the air, land, and water, endangering workers and local populations.

Despite these environmental and health concerns, informal e-waste recycling flourishes since it requires no expertise and is simple with high profit margins. The informal recycling

practices done at Shersha recycling units include manually dismantling the equipment, which is typically done by using simple tools and bare hands.



The second most common practice seen there was extracting the precious components from different e-waste items, for instance, printed circuit boards with high-powered flame torches or heating. Precious metals are also recovered using acid baths, in which old motherboards, processor chips, and other components containing precious metals are immersed in acid, melting away the plastic and leaving the metals behind. Copper is reclaimed from cables by burning off the plastic, which leaves the copper intact. These practices are done informally without any protective equipment, posing health risks to workers as well as the environment. The hazardous nature of e-waste has a variety of environmental consequences.

5.19 Consistency of Open-ended Questions with Empirical Findings

(1) Health Issues Faced by E-Waste Recycling Workers

Quantitative data helps to paint a clear picture of the scope and prevalence of health problems among e-waste recycling workers, such as the number of cases and the severity of conditions. On the other hand, qualitative data offers valuable insights into the experiences and perceptions of these workers regarding their health risks. By combining both types of data, we can gain a more complete understanding of the issues at play and develop more effective strategies for mitigating those risks.

a. **Breathing Issues and Respiratory Diseases**:

Quantitative data indicates that almost 32.5% of workers have breathing issues, supported by qualitative accounts of respiratory conditions because they've been exposed to plenty of dust and chemicals. Workers face persistent coughs and breathing problems, stressing the need for proper ventilation and respiratory protection.

b. Eye Infections:

The data exposes that 25% of workers get eye infections, validated by qualitative accounts of experience with dust and insufficient eye protection. To alleviate these issues better lighting and protective gear are crucial.

c. Skin Allergies:

Among workers, 20 percent have skin allergies according to quantitative data, with qualitative data describing hazardous materials that can cause contact dermatitis, which is an inflammation of the skin characterized by itching and redness. To avoid skin issues proper PPE and hygiene practices are crucial.

(i) Physical and Mental Stress:

There is inadequate quantification of physical and mental strain in the health problems area. However, many qualitative signals are underscoring significant physical and psychological stress, manifesting as fatigue, headaches, and sleep disturbances. The results show how significantly the working conditions affect people's well-being. A sizable 47.5 percent of the workforce says they feel a strong impact on their health and stress levels because of their job highlighting the importance of ergonomics, stress management, and counseling services.

Ensuring a safe and healthy work environment in the e-waste recycling sector is about much more than just providing the correct safety equipment. It also means offering sufficient training so that workers can understand the hazards they are facing and can take steps by themselves or collectively to reduce those risks to zero. To achieve this, employers need to make sure their workers have access not only to appropriate basic protection (such as gloves, eye protection, and a coverall) but also to laboratory tests for comprehending exposure levels for carcinogens like crystals of cadmium, lead, and other hazardous materials they might be dealing with.

(2) Physical Discomfort and Health Risks in E-Waste Recycling

Quantitative data reveals that a vast number of e-waste recycling workers experience physical distress. When they are at work, half (52%) suffer from occasional discomfort and joint stiffness, a quarter (25%) frequently suffer from joint stiffness and muscle pain, and almost 22.5%

sometimes face these symptoms. Putting together quantitative and qualitative data can help illustrate the many health hazards that workers in this sector face, as well as the difficult working conditions they labor under. Jain et al. (2023) focus on the e-waste management problem and its environmental and social impacts.

To minimize the hazards linked with these risks and enhance working conditions, several suggestions are put forward. Even further improvements can be made to enhance safety protocols. These include not just operational safety but also ergonomics and work environment. More could also be done to improve the effectiveness of personal protective equipment (PPE). It is very beneficial to have health conditions looked at frequently. Through routine check-ups, and various health problems.

(3) Health Management and Access Among E-Waste Recycling Workers

The quantitative data shows that 52.5 percent of e-waste recycling workers go to the doctor only when they feel bad or for check-ups, 42.5% rarely go for health check-ups, 2.5% regularly have health check-ups and take medications, and another 2.5% never have health check-ups or take medications.

The quantitative data showing the numerous health dangers that healthcare workers are exposed to every day is substantiated by qualitative research findings. Recycling workers work in environments where they are at high risk of contracting various illnesses, and limited access to healthcare. Both data highlight the persistent need for improvements in several areas:

Improved Health Education: Training employees to recognize the earliest signs of mental health conditions and teaching them self-care strategies can translate into faster medical treatment.

Better Health Support Systems: Offering medical care paid for by the employer, along with health insurance and health funds, can erase the financial troubles associated with accessing healthcare. Employees must have the resources to pay for medical necessities because their well-being is of utmost importance.

Regular Health Monitoring: It is very beneficial for individuals with chronic health conditions to schedule and keep routine health check-ups. These checks allow healthcare providers to maintain close monitoring of a person's condition and make any necessary adjustments in treatments or medications as needed.

Combining data from these two methods allows for a much more complete understanding of the factors that impact healthcare access and medical visit patterns among individuals in this

occupation. The concern about the health of workers working in the sites of e-waste recycling (specifically informal recycling) has risen in Asia (Ahirwar and Tripathi, 2021). Traditional techniques for the recycling of e-waste are usually adopted in Pakistan due to lack of knowledge and technological advancement (Gilal et al., 2022). The dangers to health and limited access to medical care demand urgent action to enhance the supportive structures for health, strengthen health education, and increase the frequency of health checks.

(4) Awareness and Health Risks in E-Waste Recycling Among Workers

(i) Integrated Analysis of Awareness and Training Levels

Training and awareness are sadly dissatisfactory among workers in the e-waste recycling sector, according to both qualitative and quantitative data.

Trained and Informed (22.5%): Only small number of workers receive formal training on safety measures related to e-waste recycling. The training deals with the management of hazardous materials like lead, mercury, and cadmium. These workers know all very well the health dangers associated with their line of work. They could develop respiratory illnesses, skin problems, or suffer from injuries from sharp objects and machinery.

Untrained Workers (77.5%): When it comes to e-waste recycling, most people do not receive adequate instruction regarding the potential hazards. Some workers have a vague understanding that their work presents certain hazards but do not comprehend the precise nature of those risks.

Ensuring a safe and healthy work environment is not only a legal requirement but also a moral obligation for employers. Enhancing safety programs, broadening and intensifying the reach of health risk education, and using robust safety protocols altogether generate a work environment that gives priority to the well-being of workers. (Gilal et al., 2022) and (Parvez et al., 2021) attributed the recycling behaviors associated with e-waste in households in India and Pakistan to a lack of knowledge, infrastructure, and awareness about the subject matter.

(ii) Integrated Analysis of Awareness of Health Risks

The quantitative analysis shed light on the awareness levels held by workers in relation to the health hazards tied to e-waste recycling, line up closely with qualitative findings.

High Risk Perception (22.5%): Workers in this category have a profound knowledge of the direct health threats connected to electronic waste recycling. From personal experience or familiarity, individuals are aware of how hazardous materials can affect health. For example, workers in certain sectors may understand the risks associated with lung damage and other respiratory

illnesses because they or their colleagues have been impacted by those hazards. Similarly, people living near contamination sites often know about the threats to their health and the health of their communities.

Moderate Awareness (42.5%): This group have a good grasp of the main threats but require more insight into the specific risks and ways to mitigate them.

Lack of Awareness (30%): A significant portion of workers often do not recognize the risks associated with harmful substances they work with. This lack of knowledge puts them in danger of being exposed to toxins.

Awareness Coupled with Acceptance (5%): People accept dangerous jobs due to limited options. They know the risks but choose to take them for economic reasons. The process of E-waste recycling has its problems, namely a widespread informal recycling process, low awareness levels, and a shortage of infrastructure (Kumar et al., 2017).

Combining qualitative and quantitative results underscores the grave necessity of all-encompassing safety measures and awareness programs for e-waste recycling. Combining different methods reduces work hazards for e-waste recyclers and makes their work environment safer. Additionally, the integrated approach fosters good practice that is part of a sustainable and responsible recycling process for electronic waste (e-waste).

(5) Improving Health and Safety Conditions in E-Waste Recycling

Integrating both qualitative insights and quantitative data exposes that e-waste recycling sector has serious safety and health issues that require urgent attention. To make workplaces safer and more enduring, it is necessary to improve on the safety equipment, to strengthen the training that employees undertake, to enhance the working conditions themselves, and also (and most importantly) to ensure that there is health support for all who work in them.

(6) Work Environment

To improve the safety and health e-waste recycling process, the combination of quantitative data and qualitative insights showcases the urgent need to do so. There is a need to address issues like inappropriate ventilation, poor hygiene facilities, lack of emergency response plans, and absence of safety procedures for hazardous materials. Therefore, the authors also stress the necessity of best practices including the provision of personal protective equipment (PPE), improving ventilation systems, and conducting frequent training and awareness sessions for the

workers (Imran et al., 2017). Stakeholders should make the environment better and safer for workers, by minimizing health risks and by providing working training.

CHAPTER # 06

CONCLUSION AND IMPLICATIONS

6.1 Conclusion:

The consumption of electronics has increased significantly all across the world. Because of this increased consumption, the rate at which these electronic devices get discarded has also increased significantly. This informal sector is mainly propelled by profitability and has no regulations, there is a high risk of harm to workers' health and the environment. E-waste recyclers are often in direct contact with toxic substances without proper safety gear, and they suffer from health complications.

The focus of this study is on workers' health and safety, mainly highlighting occupational hazards and health risks faced by those who are engaged in informal e-waste recycling and handling. This emphasis highlights the instant need for better working conditions and safety measures to reduce these risks and protect the well-being of workers in this sector. workers who are working in e-waste recycling to extract precious metals, burn and melt wires and cables, dismantle retired electronics, operate crusher machinery, and deal with toxic chemicals are at a high risk of getting affected by many ailments. The production of undesirable gases and pollutants while burning wires affects the human respiratory system causing breathing diseases and other health complications. Workers involved in metal melting and crushing are prone to dust and toxic fumes while handling heavy metals with effects like respiratory disorders and heavy metals poisoning. All these informal recycling procedures entail workers coming across dangerous substances such as lead, mercury, and other toxic substances that enhance the likelihood of getting poisoned, skin allergies, skin itching, rashes, and neuro disorders. The workers who work near or in contact with acids or leaching chemicals are more likely to be exposed to chemical burns and chemical fumes.

Recycling of e-waste not only threatens the health of those involved in handling the waste but also endangers the physical environment. All the burning of e-waste in Shersha Karachi was done openly at their recycling units. As a result, those who are not involved in the recycling process but are living over there are also getting affected. Nonetheless, it can be stated that informal e-waste recycling in Pakistan is highly dangerous for workers and the environment. In Pakistan solving these problems would need increased safety measures, and structures for safe recycling. To address e-waste challenges in Pakistan, the government needs to implement a comprehensive e-waste

policy, enforce strict safety regulations for handling hazardous materials, and develop robust infrastructure for safe recycling processes.

6.2 Way Forward:

This research contributes mainly to the e-waste management policy in Pakistan by offering evidence-based insights. The formulation of sustainable practices will be guided through the identification of the best practices. Effective implementation and monitoring of policies can help in ensuring the health and safety of e-waste recycling workers. The informal e-waste recycling sector in Pakistan is, currently, operating as an illegal or informal market with no legitimate regulatory structure or government authority involved. This market has specific purposes for each group of stakeholders from refurbishers to scrap dealers, brokers, and then recyclers., but not so much for the government itself. There is no transparency and accountability in the e-waste recycling business in Pakistan. E-waste Recycling is a market motivated primarily by profitability, and thus easily attracts numerous participants with little expertise and minimal infrastructure with significant profit margins. For Pakistan, full or partial formalization of the system is needed to counter e-waste. Partial formalization means that the dismantling process can be done here in Pakistan but for further recycling, e-waste should be sent to developed countries where there are proper recycling plants with strict rules and regulations to be followed.

Strong measures can be taken to prevent child labor in this recycling sector. Policy can be created to guarantee environmentally friendly and safe handling of e-waste during disposal and collection, and also prevent unsafe practices like burning by development authorities, dismantling, and dumping. Implementing Extended Producer Responsibility in Pakistan can lead to more responsible and sustainable practices in the electronics industry. The nudging techniques can be practiced for the e-waste recycling units that are engaged in this hazardous routine of child labor. It should be made compulsory for all e-waste recyclers to use Personal Protective Equipment (PPE) while at work. Workers should get occupational safety training on the appropriate use and care of PPE to prevent harm due to toxic fumes and hazardous gases. Workers should be given some sort of medical compensation by the owners of recycling units to secure their entitlement to medical services and financial support for medical fees.

References

Ackah, M. (2017). Informal E-waste recycling in developing countries: review of metal (loid) s pollution, environmental impacts and transport pathways. Environmental Science and Pollution Research, 24(31), 24092-24101.

Ahirwar, R., & Tripathi, A. K. (2021). E-waste management: A review of recycling process, environmental and occupational health hazards, and potential solutions. *Environmental Nanotechnology, Monitoring & Management*, *15*, 100409.

Alam, T., Golmohammadzadeh, R., Faraji, F., & Shahabuddin, M. (2022). E-waste recycling technologies: an overview, challenges and future perspectives. *Paradigm shift in E-waste management*, 143-176.

Annamalai, J. (2015). Occupational health hazards related to informal recycling of E-waste in India: An overview. *Indian journal of occupational and environmental medicine*, *19*(1), 61-65.

Awasthi, A. K., Zeng, X., & Li, J. (2016). Relationship between e-waste recycling and human health risk in India: a critical review. *Environmental Science and Pollution Research*, *23*, 11509-11532.

Awasthi, A. K., Li, J., Koh, L., & Ogunseitan, O. A. (2019). Circular economy and electronic waste. Nature Electronics, 2(3), 86-89.

Balasubramanian, R., & Karthikeyan, O. P. (2017). E-waste recycling environmental and health impacts. In Handbook of advanced industrial and hazardous wastes management (pp. 339-364). CRC Press.

Bhaskar, K., & Turaga, R. M. R. (2018). India's E-Waste Rules and Their Impact on E-Waste Management Practices: A Case Study. *Journal of Industrial Ecology*, *22*(4), 930-942.

Borthakur, A. and Govind, M. (2017). Emerging trends in consumers' e-waste disposal behaviour and awareness: A worldwide overview with special focus on india. Resources, Conservation and Recycling, 117:102–113.

Cao, J., Lu, B., Chen, Y., Zhang, X., Zhai, G., Zhou, G., ... & Schnoor, J. L. (2016). Extended producer responsibility system in China improves e-waste recycling: Government policies, enterprise, and public awareness. *Renewable and Sustainable Energy Reviews*, *62*, 882-894.

Castro, F. D., & Bassin, J. P. (2022). Electronic waste: Environmental risks and opportunities. In Hazardous Waste Management (pp. 421-458). Elsevier.

Chung, S. W., & Murakami-Suzuki, R. (2008). A comparative study of e-waste recycling systems in Japan, South Korea and Taiwan from the EPR perspective: implications for developing countries. *Kojima. Chiba*, *21*, 11-23.

Dey, S., Veerendra, G., Padavala, S. S. A. B., and Manoj, A. P. (2023). Recycling of ewaste materials for controlling the environmental and human heath degradation in india. Green Analytical Chemistry, 7:100085.

Dias, P., Bernardes, A. M., & Huda, N. (2019). Ensuring best E-waste recycling practices in developed countries: An Australian example. *Journal of Cleaner Production*, *209*, 846-854.

Dutta, D., & Goel, S. (2021). Understanding the gap between formal and informal e-waste recycling facilities in India. Waste Management, 125, 163-171.

Fischer, D., Seidu, F., Yang, J., Felten, M. K., Garus, C., Kraus, T., ... & Kaifie, A. (2020). Health consequences for e-waste workers and bystanders—a comparative cross-sectional study. *International Journal of Environmental Research and Public Health*, *17*(5), 1534.

Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The global e-waste monitor 2020. *United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Rotterdam*, *120*.

Gidarakos, E., Basu, S., Rajeshwari, K. V., Dimitrakakis, E., & Johri, C. R. (2012, February). E-waste recycling environmental contamination: Mandoli, India. In *Proceedings of the Institution of Civil Engineers-Waste and Resource Management* (Vol. 165, No. 1, pp. 45-52). ICE Publishing.

Gilal, F. G., Shah, S. M. M., Adeel, S., Gilal, R. G., and Gilal, N. G. (2022). Consumer e-waste disposal behaviour: A systematic review and research agenda. International Journal of Consumer Studies, 46(5):1785–1803.

Gollakota, A. R., Gautam, S., & Shu, C. M. (2020). Inconsistencies of e-waste management in developing nations–Facts and plausible solutions. Journal of environmental management, 261, 110234.

Grace Pavithra, K., Sundar Rajan, P. S., Balaji, D., and Gopinath, K. (2020). Sustainable electronic-waste management: implications on environmental and human health. E-waste Recycling and Management: Present Scenarios and Environmental Issues, pages 201–218.

Imran, M., Haydar, S., Kim, J., Awan, M. R., & Bhatti, A. A. (2017). E-waste flows, resource recovery and improvement of legal framework in Pakistan. *Resources, Conservation and Recycling*, *125*, 131-138.

ILO (2012). international labour organization.

Iqbal, M., Syed, J. H., Breivik, K., Chaudhry, M. J. I., Li, J., Zhang, G., & Malik, R. N. (2017). E-waste driven pollution in Pakistan: the first evidence of environmental and human exposure to flame retardants (FRs) in Karachi City. *Environmental science & technology*, *51*(23), 13895-13905.

Jain, M., Kumar, D., Chaudhary, J., Kumar, S., Sharma, S., & Verma, A. S. (2023). Review on E-waste management and its impact on the environment and society. *Waste Management Bulletin*.

Kaya, M., & Kaya, M. (2019). E-Waste and E-Waste Recycling. Electronic Waste and Printed Circuit Board Recycling Technologies, 1-32.

Kazim, M., Syed, J. H., Kurt-Karakus, P. B., Akcetin, M. O., Akram, S., Birgul, A., ... & Wania, F. (2023). Gaseous elemental mercury emissions from informal E-Waste recycling facilities in Pakistan. Waste Management, 170, 261-269.

Kumar, A., Holuszko, M., & Espinosa, D. C. R. (2017). E-waste: An overview on generation, collection, legislation and recycling practices. *Resources, Conservation and Recycling*, *122*, 32-42.

Kumar, S., & Singh, V. (2019). E-Waste: Generation, environmental and health impacts, recycling and status of e-waste legislation. *Journal of Emerging Technologies and Innovative Research*, *6*(1), 592-600.

Leung, A. O. W. (2019). Environmental contamination and health effects due to E-waste recycling. Electronic waste management and treatment technology, 335-362.

Li, W., & Achal, V. (2020). Environmental and health impacts due to e-waste disposal in China–A review. Science of the Total Environment, 737, 139745.

Liu, K., Tan, Q., Yu, J., & Wang, M. (2023). A global perspective on e-waste recycling. *Circular Economy*, *2*(1), 100028.

M, S. (November 2023). Unveiling the future: Trends in e-waste management.

Manasi, S. (2012). Emerging trends in e-waste management-status and issues: A case study of bangalore city. Technical report.

Noreen, F., Sajjad, A., Mahmood, K., Anwar, M., Zahra, M., & Waseem, A. (2020). Human biomonitoring of trace elements in scalp hair from healthy population of Pakistan. Biological trace element research, 196, 37-46.

Obodoeze, E. F. C., Ugwoke, F. N., & Ugwu, E. A. E-Waste Menace in Nigeria and the Way Out of it.

Okeme, J. O., & Arrandale, V. H. (2019). Electronic waste recycling: occupational exposures and work-related health effects. *Current environmental health reports*, *6*, 256-268.

Orlins, S., & Guan, D. (2016). China's toxic informal e-waste recycling: local approaches to a global environmental problem. *Journal of Cleaner Production*, *114*, 71-80.

Patil, R. A., & Ramakrishna, S. (2020). A comprehensive analysis of e-waste legislation worldwide. *Environmental Science and Pollution Research*, *27*(13), 14412-14431.

Parvez, S. M., Jahan, F., Brune, M.-N., Gorman, J. F., Rahman, M. J., Carpenter, D., Islam, Z., Rahman, M., Aich, N., Knibbs, L. D., et al. (2021). Health consequences of exposure to e-waste: an updated systematic review. The Lancet Planetary Health, 5(12):e905–e920.

Perkins, D. N., Drisse, M. N. B., Nxele, T., & Sly, P. D. (2014). E-waste: a global hazard. Annals of global health, 80(4), 286-295.

Priyashantha, A. K. H., Pratheesh, N., and Pretheeba, P. (2022). E-waste scenario in south-asia: an emerging risk to environment and public health. Environmental

Analysis, Health and Toxicology, 37(3).

Rajesh, R., Kanakadhurga, D., & Prabaharan, N. (2022). Electronic waste: A critical assessment on the unimaginable growing pollutant, legislations and environmental impacts. Environmental Challenges, 7, 100507.

Rasheed, R., Rizwan, A., Javed, H., Sharif, F., Yasar, A., Tabinda, A. B., ... & Su, Y. (2022). Analysis of environmental sustainability of e-waste in developing countries—a case study from Pakistan. *Environmental Science and Pollution Research*, *29*(24), 36721-36739.

Rene, E. R., Sethurajan, M., Ponnusamy, V. K., Kumar, G., Dung, T. N. B., Brindhadevi, K., & Pugazhendhi, A. (2021). Electronic waste generation, recycling and resource recovery: Technological perspectives and trends. *Journal of Hazardous Materials*, *416*, 125664.

Saha, L., Kumar, V., Tiwari, J., Rawat, S., Singh, J., Bauddh, K., et al. (2021). Electronic waste and their leachates impact on human health and environment: Global ecological threat and management. Environmental Technology & Innovation, 24:102049.

Sajid, M., Syed, J. H., Iqbal, M., Abbas, Z., Hussain, I., & Baig, M. A. (2019). Assessing the generation, recycling and disposal practices of electronic/electrical-waste (E-Waste) from major cities in Pakistan. Waste management, 84, 394-401.

Shaikh, S. (2021). A critical analysis of e-waste management and recycling in Pakistan: a life cycle assessment (Doctoral dissertation, Victoria University).

Shevchenko, T., Laitala, K., and Danko, Y. (2019). Understanding consumer ewaste recycling behavior: introducing a new economic incentive to increase the collection rates. Sustainability, 11(9):2656.

Sivaramanan, S. (2013). E-waste management, disposal and its impacts on the environment. *Universal Journal of Environmental Research & Technology*, *3*(5).

Song, Q., & Li, J. (2014). Environmental effects of heavy metals derived from the e-waste recycling activities in China: A systematic review. *Waste management*, *34*(12), 2587-2594.

Sthiannopkao, S., & Wong, M. H. (2013). Handling e-waste in developed and developing countries: Initiatives, practices, and consequences. *Science of the Total Environment*, *463*, 1147-1153.

THE GLOBAL E-WASTE MONITOR 2024. UNITAR. (2024). https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

Umair, S., Anderberg, S., & Potting, J. (2016). Informal electronic waste recycling in Pakistan. *The Journal of Solid Waste Technology and Management*, *42*(3), 222-235.

Unitar (2020). The global e-waste monitor 2020 – quantities, flows, and the circular economy potential.

UNSW (2016). Australian laws lag on electronic waste.

APPENDIX: A

Thematic Charts

Code 1: Roles in E-waste Recycling

Case ID	Demographics						1.1 Physical Dismantling	1.2 Melting Processes	1.3 Metal Extraction	1.4 Collection and Sorting
	Gender	Age	Education level	Monthly income (PKR)	Living Area	Years in Industry				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Hammering different parts to crush it for further recycling			
2	Male	33	Illiterate	10,000 to 15,000	korangi	4-6 years		Melting plastics for reuse		
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years			Separating metals from circuits	
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years				Breaking machines for parts
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years				Electronic waste is collected from different places

6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years	dismantle computers to harvest the material including processors, RAM, discs, and printed circuit boards		Dismantling computer parts to extract chips, gold, and silver through burning and acid leaching	
7	Male	39	Primary schooling	20,001 to 25,000	karachi	7 or more years		Melting copper wires with fire	Melting copper wires with fire	
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years	Loading, unloading, and crushing			Loading, unloading, and crushing
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years			Extracting copper from old CRT monitors and wires	
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years	Damaging board parts of computers			
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years				Separating hazardous waste
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years				Separation of e-waste by type
13	Femal e	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years				Separating valuable chips, cards, boards

14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year				Separating plastic casings
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years				Separating equipment with glass
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years		Segregating silver and copper		
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years			Burning cable wires	
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years			Burning of wires	
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years				Separating plastic casings
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years				Safely managing e-waste
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years			Burning circuit boards	
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years	Separate tiny parts			
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years	Disassembling electronics			
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years				Picking up old electronics

25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years				Wire collection
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years				Sorting and categorizing components
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years				E-waste collector and sorter
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years	Hammering and crushing			
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years	Breaking circuit boards			
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years			Burning wires for copper	
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years	Crushing machine operator			
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years	Separating cables, wires, screws			
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years	Breaking tiny parts			
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years			Burning cables and sorting	
35	Male	42	Primary schooling	20,001 to 25,000	Karachi Landhi	7 or more years		Burning circuit boards		

36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			Burning the cables to extract copper	
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years				Sorting non-recyclable plastics
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		Melting plastic for reuse		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years	Dismantling electronics			
Representative Themes	Demographics						Mechanical and Manual Dismantling of E-Waste	Thermal Processes for Metal Recovery	Separation and Sorting of E-Waste Components	Collection and Transportation of E-Waste

Code 2: Exposure Levels in E-waste Recycling

Case ID	**Demographics**						**2.1 Dismantling**	**2.2 Burning and Melting**	**2.3 Shredding /segregation**	**2.4 Manual Handling**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				

1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years		Burning of wires		
2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years	Crusher machine operators			
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years	Dismantling and burning wires	Dismantling and burning wires		
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years				Proper handling, training
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years			E-waste sorting and segregation	
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years			E-waste sorting	
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years		Fire, burning of wires		
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years		Fire, burning of wires, melting		
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years	Dismantling	Burning		

10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years				Recovering valuable material
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years	dismantling,	Burning, acid leaching		
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years			E-waste recycling plant worker	
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years		Burning circuit boards, wires, cables		
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year	Burning and crushing	Burning and crushing		
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years		Burning wires		
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years		Burning cables, circuit boards		
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years	Dismantling electronics			
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years	dismantling	Burning		

19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years		Burning cable wires		
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years	Manual separation and dismantling			Manual separation and dismantling
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years		Melting, burning wires		
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years		Burning wires		
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years		Melting wires		
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years	Dismantling	Burning		
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years		Burning of cables		
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years		Burning cables, plastic		
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years		Burning wires and plastics		

28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years	Dismantling	Melting		
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years		Burning wires and plastics		
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years		Burning, melting wires		
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years		Manual dismantling, burning		Manual dismantling, burning
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years		Burning cables		
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years		Manual dismantling, burning		Manual dismantling, burning
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years		Melting plastic, burning wires		
35	Male	42	Primary schooling	20,001 to 25,000	Karachi Landhi	7 or more years		Manual dismantling, burning		Manual dismantling, burning
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years		Burning cables		

37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years		Manual dismantling, burning		Manual dismantling, burning
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		Burning wires, plastics		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years		Manual dismantling, burning		Manual dismantling, burning
Representative Themes	Demographics						Mechanical Crushing and Manual Dismantling	Thermal Processes and Metal Extraction	Sorting and Handling of E-Waste	Chemical Processing and Acid Leaching

Code 3: Health Issues among Workers Before Entering E-Waste Recycling

Case ID	**Demographics**						**3.1 No Pre-Existing Health Issues**	**3.2 Specific Health Issues Prior to Job**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**		
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Never ailed before this profession	
2	Male	33	Illiterate	10,000 to 15,000	korangi	4-6 years	No job-related health challenges before.	
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years	Healthy before joining here.	
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years	No health issues before this job.	
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years		Had eye redness sometimes.
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years		Had joint and back pain before

7	Male	39	Primary schooling	20,001 to 25,000	karachi	7 or more years	No diseases before joining this job	
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years	Good health before joining	
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years		Occasional joint pains
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years	Fine except for occasional sickness	
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years	No illnesses before starting	
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years	Maintained good health before	
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years	None	
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year		Had joint pains and asthma.
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years	No serious health issues	
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years	Free from disease before recycling job.	
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years	No health problems before	
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years		Had a kidney issue for a long time.
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years	Never had any illness before	
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years	Not sick of any diseases before.	
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years		Had stomach problems
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years	No diseases before entering this field.	
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years	No major health issues.	
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years	Good health and fitness before	
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years	No health problems before.	

26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years	No disease/ailment before starting work	
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years	No illnesses before joining	
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years	No major health issues at all	
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years	No health problems when I started	
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years	No medical issues	
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years		Body pain from previous job as vegetable seller
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years	Good physical condition before.	
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years	No health problems before this job	
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years	Healthy all the time before this job	
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years	Not sick before joining as recycler	
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years		Affected by COVID but no other diseases
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years	No health issues prior to starting work.	
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years	No health issues related to this job before joining	
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years		Some body pain before, now more severe
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years	Haven’t had any.	
Representative Themes	Demographics						Majority in Good Health Prior to Joining	Minor Pre-existing Health Conditions

Code 4: Health Deterioration Among Workers After Joining E-Waste Recycling

Case ID	Demographics						4.1 No Effect on Health	4.2 Physical Discomfort/Muscle pain /Stress	4.3 Respiratory Issues	4.4 Eye Infection / Skin Allergies
	Gender	Age	Education level	Monthly income (PKR)	Living Area	Years in Industry				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	No, I don't feel any health problems			
2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years	No, I don't feel any major change in my health status			
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years		Sometimes symptoms like headache, sometimes not.		
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years				Airborne particles cause eye and skin issues.

5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years		Job exposure leads to diseases, headaches, fatigue		
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years		Body aches from repetitive tasks and heavy lifting		
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years				Eyesight issues from particles and low light.
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years		Increased fatigue, stress, and colds.		
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years		Uncertain if job or age causes tiredness and headaches.		
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years			Lung issues, eye infections, and skin allergies from dust and chemicals	Lung issues, eye infections, and skin allergies from dust and chemicals
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years		Coughing and skin allergies.		Coughing and skin allergies.
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years		Bad air quality and physical stress.		
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years		Back pain and skin irritation		Back pain and skin irritation
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year		Health affected; environment not good		
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years		Back pain, respiratory issues from dust and fumes.	Back pain, respiratory issues from dust and fumes.	

16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years		Frequent cuts and bruises from handling sharp objects		
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years	Health same as before, sometimes restless			
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years		Extreme stress, headaches, sleep issues, but happy with work		
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years				Eye infection from harmful gases and dust
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years		Breathing issues and stress from poor air quality.	Breathing issues and stress from poor air quality.	
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years	Poor environment but happy working.	Poor environment but happy working.		
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years		Health affected, restlessness, and back pain		
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years		Fatigue, breathing issues, hand injuries	Fatigue, breathing issues, hand injuries	
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years			Respiratory problems from dust and particles.	
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years		Health affected, tough job, done for money.		

26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years				Skin irritation from handling hazardous substances
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years	Fit till now			
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years		Back pain, headaches, breathing problems from job stress	Back pain, headaches, breathing problems from job stress	
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years		Uncertain if job or hazardous air affects health		
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years	Health not affected by job.			
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years		Overall health declined, possibly due to age		
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years		Back pain increased from job		
33	Female	26	Illiterate	15,001 to 20,000	She Sha Karachi	1-3 years		Increased back pain and skin problems from hazardous materials.		Increased back pain and skin problems from hazardous materials.
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years		Uncertain if job affects health, faces extreme headaches		
35	Male	42	Primary schooling	20,001 to 25,000	Karachi Landhi	7 or more years		Toxic material affects eyes and stomach		Toxic material affects eyes and stomach

36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			Slight health issues like coughing, skin irritation.	Slight health issues like coughing, skin irritation.
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years		Back pain increased after starting job		
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		Body aches from tiring tasks		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years			Respiratory issues and regular colds from poor air quality	
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years		Overall health declined, more tired and stressed.		
Representative Themes	Demographics						Perception of No Health Impact	Physical and Mental Stress	Respiratory Issues	Eye Infections and Skin Allergies

Code 5: Frequency of Doctor Visits Among E-Waste Recycling Workers

Case ID	**Demographics**						**5.1 Frequent Visits (Monthly or More Often)**	**5.2 Regular Visits (Every 2-3 Months)**	**5.3 Rare or As-Needed Visits**	**5.4 Infrequent or Annual Visits**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Monthly due to job stress and			

							exposure to risks			
2	Male	33	Illiterate	10,000 to 15,000	korangi	4-6 years	Monthly for extreme symptoms			
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years			Rarely, only for critical situations	
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years				Annually for routine check-ups, job hazards
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years	Monthly or bi-monthly for respiratory illness			
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years	2-3 times per month due to asthma and skin issues			
7	Male	39	Primary schooling	20,001 to 25,000	karachi	7 or more years			Only for severe symptoms	
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years		Every three months due to job stress and age		
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years			Only when necessary due to lack of money	
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years		Bi-monthly due to financial constraints		
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years		Every 2-3 months for diseases		
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years			Only for severe	

									symptoms like skin issues	
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years		Every 2-3 months or when severe		
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year			Only when seriously ill	
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years			When coughing becomes unbearable	
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years	1-2 times a month due to constant health issues			
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years		2-3 times every two months for complications		
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years			Only if financially able	
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years	Monthly or bi-monthly for asthma			
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years	Up to three times a month based on health			
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years			When necessary, despite low wage	
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years		Every two months for respiratory and skin issues		
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years	Twice a month for severe problems			

24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years				No need due to good health
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years			Once since starting job	
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years			Occasionally for health issues	
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years	Every 4-5 months for respiratory issues			
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years			Only when necessary	
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years				Annually unless major issue arises
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years	Monthly for recurring problems			
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years			Occasionally, based on severity, prefer not to go	
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years				No need due to good health
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years				Long time since last visit
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years			When extremely sick, otherwise self-medicate	
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years			Only for extreme needs, last	

									visit a year ago	
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			When coughing becomes unbearable	
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years				No need due to good health
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years			Only if very urgent due to financial constraints	
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years		Monthly for severe respiratory problems		
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years				Last visit 7 months ago for joint and back pain
Representative Themes	Demographics						Frequent Medical Visits Due to Job-Related Health Issues	Routine Medical Check-Ups for Chronic Conditions	Occasional Medical Visits Based on Severity of Symptoms	Infrequent Medical Visits Due to Financial Constraints

Code 6: Correlation Between Job Exposure and Health Problems in E-Waste Recycling

Case ID	**Demographics**						**6.1 Toxic fumes**	**6.2 Toxic/Polluted work environment**	**6.3 Stressful and Tiring Job**	**6.4 No Correlation / No Knowledge**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				

1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Yes, due to burning wires, chips, boards, etc			
2	Male	33	Illiterate	10,000 to 15,000	korangi	4-6 years		Yes, dismantling causes dust and breathing issues		
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years	Yes, toxic fumes directly affect health			
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years			Yes, working conditions are tiring and stressful	
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years			Yes, job affects physical and mental health, very stressful	
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years		Yes, poor air quality and hectic work		
7	Male	39	Primary schooling	20,001 to 25,000	karachi	7 or more years	Yes, maybe due to burning, dismantling, acid leaching			
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years				I don't know
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years	Yes, toxic fumes, flying ashes, and noise affect health			
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years				Sometimes, but I'm not sure

11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years		Yes, toxic work environment affects health		
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years		Yes, hazardous nature of e-waste recycling		
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years	Yes, burning and dismantling harmful			
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year				Maybe, but I'm not sure
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years				Maybe, but I'm not sure
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years		Yes		
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years		Yes		
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years				I have no idea
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years				Maybe
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years	Yes, physical hazards and injuries			
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years				No Correlation
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years			Yes, very stressful and tiring, frequent body aches	
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years		Yes, breathing issues and coughing		
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years		Yes, respiratory problems and skin itching		

25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years		Yes		
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years			Yes, dismantling and crushing are tiring and stressful	
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years	Yes, toxic fumes and gases affect health			
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years		Yes		
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years				No, I haven't had symptoms
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years		Yes, airborne particles harm the lungs		
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years		Yes, toxic environment affects health		
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years		Yes, e-waste recycling exposure harms health		
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years				I have no idea
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years				No, I haven’t had health problems
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years	Yes, dust, toxic fumes, and gases cause breathing issues			
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			Yes, e-waste recycling is	

									rough and tiring	
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years				Maybe, but I haven't had symptoms
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		No, but sometimes eye infection from burning		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years	Yes, dust, toxic fumes and gases cause breathing issues			
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years	Yes, toxic pollutants and chemicals cause skin issues			
Representative Themes	Demographics						Toxic Fumes and Health Hazards in E-Waste Recycling	Health Issues and Environmental Concerns in E-Waste Recycling	Stressful and Tiring Working Conditions in E-Waste Recycling	Explicit Denial or Lack of Awareness of Correlation

Code 7: Awareness of potential hazards

Case ID	**Demographics**						**7.1 Chemical and Toxic Element Exposure**	**7.2 Physical Injuries**	**7.3 Unawareness**	**7.4 General Health Impact**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years			No, I am not aware of potential hazards	

2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years		Hands frequently injured by sharp edges		
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years	Suffered from toxic elements like lead, mercury			
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years			No, I do not know about any hazards	
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years				Skin rash and breathing difficulties due to toxic gases
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years				Harmful to health, but satisfied with job
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years			No, I am not aware of potential hazards	
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years			No, I am not aware of potential hazards	
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years	Toxic chemicals like lead and mercury damage health			
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years			No, I don't know about potential hazards	
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years				Aware of hazards, but can't use gloves

12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years			No, I am not aware of potential hazards	
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years			No, I am not aware of potential hazards	
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year			No, I am not aware of potential hazards	
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years			No, I am not aware of potential hazards	
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years			No, I am not aware of potential hazards	
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years			No, I am not aware of potential hazards	
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years			No, I am not aware of potential hazards	
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years	Burning e-waste releases toxic fumes			
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years		Injury risk, skin rashes, respiratory distress		Injury risk, skin rashes, respiratory distress
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years			No, I am not aware of	

									potential hazards	
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years			No, I am not aware of potential hazards	
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years				Yes, aware of potential hazards
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years		Dismantling causes back pain		
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years			No, I am not aware of potential hazards	
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years				Toxic, risky, and stressful job
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years			No, I am not aware of potential hazards	
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years				Aware of potential hazards, but limited knowledge
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years			No, I am not aware of potential hazards	
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years			No, I am not aware of potential hazards	
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years	Pollution harms us, limited knowledge			
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan	4-6 years	Smoke and gases are			

					Colong Karachi		harmful to health			
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years			No, I am not aware of potential hazards	
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years			No, I am not aware of potential hazards	
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years			No, I am not aware of potential hazards	
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			No, I am not aware of potential hazards	
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years			No, I am not aware of potential hazards	
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		Breathing issues, stress, and physical injuries		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years				E-waste is bad for health
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years	Burning machine operator, high fire risk			
Representative Themes	Demographics						Awareness of Specific Health Hazards	General Awareness of Harm but Lack of	Lack of Awareness	Awareness Coupled with Acceptance or Resignation

			Detailed Knowledge		

Code 8: Recycling methods

Case ID	Demographics						8.1 Sorting/Separation	8.2 Melting/Burning	8.3 Crushing /Hammering	8.4 Dismantling /Segregation	8.5 Extractions
	Gender	Age	Education level	Monthly income (PKR)	Living Area	Years in Industry					
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years		Burning, dumping in containers, melting plastics and wires			
2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years	Separating metals from circuits, crushing machines for metal parts		Separating metals from circuits, crushing machines for metal parts		
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years		Recycling plastics and wires through melting			
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years			Crushing machine for metal parts after dismantling	Crushing machine for metal parts after dismantling	

5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years					Shredding motherboard for components
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years				Disassemblin g computers manually by hand	
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years		Burning and dumping of e-waste			
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years			Crushing and dismantling IT scrap, dumping leftover waste	Crushing and dismantling IT scrap, dumping leftover waste	
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years		Segregation, extracting metals by burning and crushing	Segregation, extracting metals by burning and crushing	Segregation, extracting metals by burning and crushing	Segregation, extracting metals by burning and crushing
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years					Extracting valuable materials after shredding e-waste
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years	Burning, segregation, dismantling, acid leaching, hammering	Burning, segregation, dismantling, acid leaching, hammering	Burning, segregation, dismantling, acid leaching, hammering	Burning, segregation, dismantling, acid leaching, hammering	
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years	Material extraction,				Material extraction,

							magnetic separation				magnetic separation
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years	Separation of items, burning wires and cables	Separation of items, burning wires and cables			
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year	Separating motherboards, wires, cables, etc				
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years	Shredding and crushing, physical pre-processing		Shredding and crushing, physical pre-processing		
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years		Burning motherboards, extracting precious metals			Burning motherboards, extracting precious metals
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years		Burning plastic, cables, wires, and crushing metal items	Burning plastic, cables, wires, and crushing metal items		
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years		Extraction and burning, further crushing shredded pieces	Extraction and burning, further crushing shredded pieces		Extraction and burning, further crushing shredded pieces
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years		Crushing, burning, melting, changing daily	Crushing, burning, melting, changing daily		

20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years	Mixed waste collection, hazard removal, shredding, sorting				
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years	Sorting and dismantling, cleaning, shredding			Sorting and dismantling, cleaning, shredding	
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years	Shredding, magnetic separation to extract metals				Shredding, magnetic separation to extract metals
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years		Crushing manually, burning in plants	Crushing manually, burning in plants		
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years					Shredding e-waste into smaller pieces to extract metals
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years	Sorting, categorization, disassembling, shredding			Sorting, categorization, disassembling, shredding	
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years	Sorting materials such as plastics and glass				
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years		Burning wires for copper extraction			Burning wires for copper extraction

28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years		Crushing and burning for extraction	Crushing and burning for extraction		Crushing and burning for extraction
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years		Burning, hammering, crushing	Burning, hammering, crushing		
30	Male	35	Illiterate	15,001 to 20,000	Liaquataba d	4-6 years		Burning wire for copper extraction			Burning wire for copper extraction
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years				Disassemblin g computers by hand, recovering precious materials	Disassemblin g computers by hand, recovering precious materials
32	Male	23	Secondar y schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years	Crushing machine for metal parts, magnetic separation		Crushing machine for metal parts, magnetic separation		
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years	Sorting, dismantling, separating materials			Sorting, dismantling, separating materials	
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorlin e karachi	1-3 years	Sorting, dismantling, shredding, burning, extracting metals	Sorting, dismantling, shredding, burning, extracting metals		Sorting, dismantling, shredding, burning, extracting metals	Sorting, dismantling, shredding, burning, extracting metals
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years		Melting plastics for reuse			
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years		Burning, crushing for metal extraction	Burning, crushing for metal extraction		Burning, crushing for metal extraction

37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years			Crushing with machines		
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years	Separating plastic materials, removing plastic casings				
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years	Dismantling printers, sorting parts for reuse or recycling			Dismantling printers, sorting parts for reuse or recycling	
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years	Sorting batteries by type for proper recycling				
Representative Themes	Demographics						Comprehensive Sorting and Separation Processes	Burning and Melting for Material Extraction	Crushing and Shredding for Reusable Parts	Manual Dismantling and Sorting	Varied Recycling Methods and Adaptability

Code 9: Disposal Procedures for Waste Generated in E-Waste Recycling

Case ID	**Demographics**						**9.1 Burning**	**9.2 Dumping**	**9.3 Collection & Pickup**	**9.4 Storage**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Wires burn in hot chambers for melting and then poured into containers			

2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years			Leftover waste is taken to city garbage site for disposal in accordance with laws	
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years		Leftover waste is thrown away in big dumpsters or in bags for municipal services pickup		
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years		Leftover waste is buried in the ground sometimes; waste may be disposed of in landfills		
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years			Leftover waste is given to local waste collectors for transport and disposal	
6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years		Leftover waste is thrown away in big dumpsters or dumped in vacant areas		
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years	Wires burn in hot chambers for melting and then poured into containers; incineration emits toxic gases			

8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years		Waste is handled directly with bare hands and dumped in empty plots		
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years	Non-recyclable waste is taken to an open space and then burned			
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years				Collections, storages, manual sorting, dismantling, shredding, mechanical separation, and recovery
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years	Leftover waste is carried to an open-air place and burned			
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years				
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years	Non-recyclable waste is usually subjected to burning			
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year	Leftover waste is either burnt or thrown away in dumpsters			
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years	Waste is burnt in open spaces, uncontrolled incineration			

16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years			Leftover waste is filled in bags and picked up by the waste pickup container	
17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years		Non-hazardous e-waste components are shredded; leftover waste is dumped in landfills or picked up by local waste collector		
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years				Designated bins are used for different types of e-waste to facilitate proper disposal
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years	Burning leftover waste emits poisonous gases affecting the community			
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years		Manual sorting, collections, shredding, and separation; residual waste left at designated dumping sites for scheduled pickup	Manual sorting, collections, shredding, and separation; residual waste left at designated dumping sites	Manual sorting, collections, shredding, and separation; residual waste left at designated

									for scheduled pickup	dumping sites for scheduled pickup
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years			Leftover waste is filled in bags and picked up by the local waste collector	
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years	Manual sorting, dismantling, separation, and burning of non-recyclable waste			
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years	Recycle as much as possible; leftover waste is burnt			
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years		After disassembly and extraction of valuable materials, waste is thrown in a dumpster		
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years			Waste is stored in designated areas and then picked up by the local waste collector	Waste is stored in designated areas and then picked up by the local waste collector
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years		Leftover waste is dumped in nearby empty plots; approximately		

								20 to 30 kg of waste daily		
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years		Leftover waste is thrown in different landfills		
28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years		Leftover waste is left on waste dumping sites for pickup; approximately 3 to 4 bags daily	Leftover waste is left on waste dumping sites for pickup; approximately 3 to 4 bags daily	
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years	Waste is picked up in containers and burnt far from the city			
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years		Leftover waste is dumped in empty plots and picked up by waste collector	Leftover waste is dumped in empty plots and picked up by waste collector	
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years		Leftover waste after recycling is thrown away in a big dumpster		
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years	Waste burnt in open spaces, uncontrolled incineration			
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years	Waste is carried by a waste carrier container and then burnt		Waste is carried by a waste carrier container and then burnt	

34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years	After collections, dismantling, separation, and recycling, leftover waste is burnt			
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years	Waste that cannot be processed further is disposed of in open spaces or burnt			
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years	After recycling, segregation, and dismantling, leftover waste is burnt in open spaces			
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years	Leftover waste is dumped in empty plots or burnt	Leftover waste is dumped in empty plots or burnt		
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years		Leftover waste is buried in the ground and sometimes left on the street for pickup		
39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years			Leftover waste is given to the local waste collector	
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years			After sorting, dismantling, and segregation, waste is bagged for pickup by local	

									waste management services	
Representative Themes	Demographics						Burning and Incineration of Leftover Waste	Dumping in Landfills and Open Spaces	Collection and Transport to Designated Disposal Sites	Organized Storage and Collection Processes

Code 10: Improving Health and Safety Conditions in E-Waste Recycling

Case ID	**Demographics**						**10.1 Safety Tools / Training**	**10.2 Satisfied / No Issue**	**10.3 Working Environment**	**10.4 Medical & Other Facilities**
	Gender	**Age**	**Education level**	**Monthly income (PKR)**	**Living Area**	**Years in Industry**				
1	Male	33	Primary schooling	15,001 to 20,000	Karachi lyari	1-3 years	Provide safety tools			
2	Male	33	Illiterate	10,000 to 15,000	Korangi	4-6 years				Provide clean drinking water and hygiene facilities
3	Male	28	Primary schooling	15,001 to 20,000	karimabad Karachi	4-6 years	enforce safety rules strictly			
4	Male	44	Primary schooling	20,001 to 25,000	karachi lyari	7 or more years			Improve the environment	
5	Male	47	Illiterate	25,001 to 30,000	Sultanabad Karachi	7 or more years				Provide clean drinking water

6	Male	46	Primary schooling	20,001 to 25,000	karachi kimari	4-6 years	Provide safety gear and training			
7	Male	39	Primary schooling	20,001 to 25,000	Karachi	7 or more years		No idea		
8	Male	49	Primary schooling	20,001 to 25,000	karachi orangi	7 or more years	Provide safety tools			
9	Male	39	Primary schooling	20,001 to 25,000	shersha karachi	4-6 years	Provide medical support and protection equipment			Provide medical support and protection equipment
10	Male	22	Primary schooling	15,001 to 20,000	orangi town karachi	7 or more years				Work under a shed and address health issues
11	Male	42	Primary schooling	25,001 to 30,000	orangi town karachi	7 or more years	Enforce safety measures			
12	Male	32	Illiterate	15,001 to 20,000	Saddar karachi	1-3 years			Improve recycling technologies	
13	Female	25	Primary schooling	20,001 to 25,000	Lyari Town karachi	7 or more years				Provide clean water and medical support
14	Male	19	Primary schooling	15,001 to 20,000	Malir Town karachi	Less than 1 year				Increase wages for health expenses
15	Male	20	Illiterate	25,001 to 30,000	Lyari Town Krachi	7 or more years			Minimize working hours	
16	Male	28	Illiterate	25,001 to 30,000	Lyari Town Karachi	4-6 years				Maintain a clean work environment and provide meal areas

17	Male	46	Primary schooling	35,001 to 45,000	korangi town Karachi	7 or more years				Better wages for overall well-being
18	Male	22	Primary schooling	15,001 to 20,000	Orangi town, Karachi	1-3 years		Satisfied with work		
19	Male	38	Illiterate	35,001 to 45,000	Shersha karachi	7 or more years				Provide medical care and first aid
20	Male	26	Secondary schooling	20,001 to 25,000	metroville area site karachi	4-6 years				Provide break, meal, and changing areas
21	Male	31	Illiterate	35,001 to 45,000	Orangi town	7 or more years		Satisfied with work		Improve wages, otherwise satisfied
22	Male	43	Primary schooling	25,001 to 30,000	lyari Aagra Taj karachi	7 or more years				Improve wages
23	Male	40	Illiterate	25,001 to 30,000	Sher Shah Karachi	7 or more years	Provide safety tools and training		Minimize working hours	
24	Male	24	Primary schooling	15,001 to 20,000	Dastageer karachi	1-3 years	Provide protective equipment and enforce safety			
25	Male	27	Illiterate	15,001 to 20,000	Kharadar area karachi	4-6 years				Install proper ventilation
26	Male	35	Secondary schooling	25,001 to 30,000	North karachi	7 or more years	Provide regular training and education			
27	Male	28	Primary schooling	15,001 to 20,000	Baldia town karachi	1-3 years			Properly dispose of toxic waste	

28	Male	24	Illiterate	20,001 to 25,000	Lyari town karachi	4-6 years			Minimize hours and ensure safety	
29	Male	28	Illiterate	25,001 to 30,000	Orangi town karachi	1-3 years		Satisfied, family's only income source		
30	Male	35	Illiterate	15,001 to 20,000	Liaquatabad	4-6 years	Provide safety tools and self-training			
31	Male	58	Illiterate	25,001 to 30,000	limes area Karachi	7 or more years			Ensure safe working conditions and hours	
32	Male	23	Secondary schooling	15,001 to 20,000	Metrovil Pathan Colong Karachi	4-6 years	Urgently need safe tools and equipment			
33	Female	26	Illiterate	15,001 to 20,000	She Sha karachi	1-3 years		Satisfied		
34	Male	17	Primary schooling	10,000 to 15,000	Ranchorline karachi	1-3 years				Provide a shed area
35	Male	42	Primary schooling	20,001 to 25,000	Karachi landhi	7 or more years			Properly dispose of toxic waste	
36	Female	37	Illiterate	25,001 to 30,000	near sher sha Krachi	7 or more years			Increase waste, work is rough	
37	Male	35	Illiterate	20,001 to 25,000	Orangi town karachi	7 or more years	Provide safety tools			
38	Male	40	Illiterate	20,001 to 25,000	Baldia Town Karachi	7 or more years			Provide a better working environment	

39	Male	52	Primary schooling	25,001 to 30,000	liyari karachi	7 or more years	Enforce safety rules strictly			
40	Male	39	Secondary schooling	25,001 to 30,000	Banaras Karachi	7 or more years	Provide hazardous materials training			
Representative Themes	Demographics						Enhanced Safety Gear and Training	Satisfaction with Current Work Conditions	Improved Working Conditions	Healthcare Support and Compensation

CODES AND SUBCODES

Table: Codes and Sub-codes

CODE ID	CODE DESCRIPTION	SUB-CODES
1	Roles in E-waste Recycling	1.1 Physical Dismantling 1.2 Melting Processes 1.3 Metal Extraction 1.4 Collection and Sorting
2	Exposure Levels in E-waste Recycling	2.1 Dismantling 2.2 Burning and Melting 2.3 Shredding /segregation 2.4 Manual Handling
3	Health Issues among Workers Before Entering E-Waste Recycling	3.1 No Pre-Existing Health Issues 3.2 Specific Health Issues Prior to Job
4	Health Deterioration Among Workers After Joining E-Waste Recycling	4.1 No Effect on Health

		4.2 Physical Discomfort/Muscle pain /Stress 4.3 Respiratory Issues 4.4 Eye Infection / Skin Allergies
5	Frequency of Doctor Visits Among E-Waste Recycling Workers	5.1 Frequent Visits (Monthly or More Often) 5.2 Regular Visits (Every 2-3 Months) 5.3 Rare or As-Needed Visits 5.4 Infrequent or Annual Visits
6	Correlation Between Job Exposure and Health Problems in E-Waste Recycling	6.1 Toxic fumes 6.2 Toxic/Polluted Work Environment 6.3 Stressful and Tiring Job 6.4 No Correlation / No Knowledge
7	Awareness of potential hazards	7.1 Chemical and Toxic Element Exposure 7.2 Physical Injuries 7.3 Unawareness 7.4 General Health Impact
8	Recycling methods	8.1 Sorting/Separation 8.2 Melting/Burning 8.3 Crushing/Hammering 8.4 Dismantling 8.5 Extractions
9	Disposal Procedures for Waste Generated in E-Waste Recycling	9.1 Burning

		9.2 Dumping 9.3 Collection & Pickup 9.4 Storage
10	Improving Health and Safety Conditions in E-Waste Recycling	10.1 Safety Tools / Training 10.2 Satisfied / No Issue 10.3 Working Environment 10.4 Medical & Other Facilities

APPENDIX: B

Questionnaire

1. Gender:
    - Male
    - Female
    - Other
2. Age: _____
3. Education level
    - Illiterate
    - Primary schooling
    - Secondary schooling
    - Matriculation
    - Intermediate
4. Monthly income (PKR)
    - Less than 10,000
    - 10,000 to 15,000
    - 15,001 to 20,000
    - 20,001 to 25,000
    - 25,001 to 30,000
    - 35,001 to 45,000
    - More than 45,000
5. Where are you currently living?
    - _____
6. How many years have you been working in the e-waste recycling industry?
    - Less than 1 year
    - 1-3 years
    - 4-6 years
    - 7 or more years
7. What is your primary job in e-waste recycling?

- _____

8. Do you recycle formally or informally?
    - _____

Exposure

9. Around how much quantity of e-waste you recycle in a day?
    - _____
10. What specific e-waste materials do you come into contact with daily tasks?
    - _____
11. Which job role is more exposed to e-waste recycling?
    - _____

Health Awareness

12. Before joining present profession, were you suffering from any disease? If yes, then what disease please specify?
    - _____
      _____
      _____
13. Do you think after coming into this job your health is affected? If yes, then explain how?
    - _____
      _____
      _____

14. Which of the following health issues are aggravated after joining this job?
    - Asthama
    - Lungs
    - Skin allergy
    - Eyes infection
    - Stomach issues
    - Respiratory
    - _____
15. How frequently do you visit doctors after joining this job?
    - _____
      _____
16. Do you think there is any correlations between your job exposure and health problems?

- _____
  _____

17. Are you aware of the potential hazards associated with e-waste materials recycling?

- _____
  _____

Safety Precautions and trainings

18. Are you provided with training or knowledge on health and safety practices related to e-waste handling?
    - Yes
    - No
    - If yes, please specify what type of training?

19. Which of the following Personal Protective Equipment (PPE) do you use regularly for your job in e-waste recycling? (Select all that apply)
    - Gloves
    - Work shoes/boots
    - Nose masks (or cloth handkerchiefs improvised as nose mask)
    - Any form of head cover
    - Safety glasses/eye protection
    - Ear plugs
    - Coverall/protective work clothes
    - none

20. Do you change your work clothes after finishing your tasks for the day?
    - Always
    - Sometimes
    - Rarely
    - Never

21. Are there emergency response plans in case of accidents or spills involving e-waste materials?
    - Yes
    - No

22. Do you have access to medical support or emergency services in case of health issues at work?
    - Yes
    - No
    - If yes, please specify what type of support is this?

_____
_____

Work Environment

23. Are there ventilation systems in place to reduce exposure to airborne pollutants in your workplace?
    - yes
    - No
24. Are there measures in place to prevent exposure to harmful fumes or gases released during e-waste recycling processes?
    - Yes
    - No
    - If Yes, please specify what is it?

_____
_____

25. Are there designated areas for breaks and meals to minimize exposure to e-waste contaminants?
    - Yes
    - No
26. Are there facilities for washing hands and maintaining personal hygiene after handling e-waste?
    - Yes
    - No

Recycling Methods

27. What are the recycling methods you follow on daily basis? Based on E-waste type.
    - _____
      _____
      _____

28. Are there protocols for the safe handling and disposal of potentially explosive e-waste items like batteries, as well as for hazardous waste generated during e-waste recycling?
    - Yes
    - No
    - If yes, could you briefly outline the procedures in place?

_____
_____

29. What procedures are in place for the disposal of waste generated during the e-waste recycling process? Please provide details about how this waste is handled, dumped, and disposed of responsibly.
    - -
      _____
      _____
      _____

30. Around how much quantity of e-waste is recycled, wasted, dumped and burned on daily basis?

_____
_____
_____

Health Conditions

31. Do you currently have any complaints or health issues such as skin allergy, lungs problems, respiratory issues, eyes infection etc. attributed to your work in e-waste recycling? If any, please describe.
    - _____
      _____
32. Have you ever experienced any vision, hearing, skin and respiratory problems that you believe may be related to your work in e-waste recycling?
    - Yes
    - No
33. How often you experience above mentioned disease attacks?
    - Frequently
    - Occasionally
    - Rarely

- Never

34. How often do you experience physical discomfort, such as muscle pain or joint stiffness, during or after work hours?
    - Frequently
    - Occasionally
    - Rarely
    - Never
35. On a scale of 1 to 5, how would you rate the overall impact of your work on your health and stress levels?
    - 1 (Very Low Impact)
    - 2 (Low Impact)
    - 3 (Moderate Impact)
    - 4 (High Impact)
    - 5 (Very High Impact)
36. Have you ever experienced any injuries or accidents while working with e-waste materials?
    - Yes
    - No
37. How often do you undergo health check-ups related to your work, also how often do you take medicines? And what medicine please specify --------
    - Regularly
    - Occasionally
    - Rarely
    - Never
38. In your opinion, what improvements could be made to enhance health and safety conditions in the e-waste recycling industry?

APPENDIX C

Interview Guide for E-waste Scrap Dealers:

Table: Interview guide for scrap dealers

Stakeholder	Questions / Issues discussed

IT Scrap & Refurbished equipment seller	• Who are the buyers? • Where e-waste is recycled? • From whom do you buy equipment? • Where are the scrap Dealers' warehouses located? • What happens to the equipment if it is completely scrap?
Electronic Scrap Dealers	**Quantity of E-Waste:** •On average, how much e-waste is collected at your facility per day? •Are there any significant fluctuations in e-waste collection throughout the year? **Types of E-Waste:** •What types of electronic equipment are most commonly collected/recycled at your facility? •Are there any specific categories of e-waste that are more challenging to handle or process? **Assessment Techniques:** •How do you assess the condition and value of incoming e-waste items? •Are there any specific criteria or guidelines used for assessing e-waste? **Sales and Recycling:** •What percentage of collected e-waste is sold to recyclers or other parties for processing? •What is the procedure for selling e-waste to recyclers or buyers?