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# Evaluating E-Waste Management Skills Development among Informal Sector Workers in Rwanda: A Case Study of Kigali City

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## Abstract

The highest consumption of electronic goods is generating E-wastes which are causing global worry, being exacerbated in cities of developing countries. This study aimed to evaluate and explore the existence of different skills development approaches towards proper e-wastes management among informal workers in Kigali City, Rwanda. Quantitative method by using a questionnaire was used to acquire primary data. Data collected were analysed using SPSS version 27.0. Different skills development approaches were explored among the informal workers, of which were informational materials (15%), online resources (35%), school curriculum (30%), and trainings (25%), while 25% responded none to learn about e-waste. Only 40% was found to be familiar with e-wastes management. The study revealed that preference of e-waste disposal in informal sector was at 70% to general solid waste collectors, and there is significant correlation (r=0.684, p-value=0.001) between skills development and e-waste management. Therefore, the development of specialised trainings with accessible educational resources will foster e-waste management practices in informal sector.

**Keywords**: *E-wastes management, Skills development, informal workers, Informal sector, Kigali City*

## 1.0 Introduction

Technology has become an integral part of modern life, providing people with numerous benefits across nearly every area of daily activity. However, the rapid adoption of emerging electronic products poses challenges for the linear economy in managing e-waste, exacerbated by the increasing use of electronic equipment driven by lifestyle changes and technological advancements (Sharma, Joshi and Kumar, 2020). The pursuit of novelty and innovation may decrease the lifespan of electronic products, contributing to the proliferation of e-waste generation systems (Wei and Liu, 2012). Once these products reach the end of their life cycle, they are deemed hazardous to the environment and human health (Onyara, 2020). E-waste, also known as electronic and electrical waste, poses a significant global challenge due to its non-biodegradable nature and rapid growth, estimated at an annual rate of 3-5%, nearly three times faster than ordinary municipal solid waste (Verma and Prakash, 2020).

Several reasons contribute to the rise in electronic waste (e-waste), such as the accessibility of products in developing nations, the expansion of markets in developed countries, and the quick obsolescence of electronic devices due to lower prices and higher internet usage. Governments, individuals, and researchers worldwide are growing more alarmed about the adverse environmental and human health effects caused by this increase in e-waste. According to a 2018 United Nations Environment Program (UNEP) report, the global production of e-waste is estimated to be between 20 and 50 million tons each year (Reuter *et al.*, 2013). Research indicates that around 20% to 25% of electronic waste (e-waste) is properly recycled in Europe and the United States (Forti *et al.*, 2020). Additionally, substantial informal recycling sectors are present in China and India, fuelled by their sizable populations (Forti *et al.*, 2020). Research conducted in China has underscored the negative environmental and human health impacts caused by rudimentary recycling techniques and the handling of substantial amounts of processed e-waste, resulting in soil and water pollution (Frazzoli *et al.*, 2010).

Moreover, Kahhat et al., (2008) found that individuals involved in handling e-waste face elevated risks of various health problems, including birth defects, infant mortality, tuberculosis, blood disorders, immune system abnormalities, kidney and respiratory impairments, lung cancer, skin conditions, developmental issues in children's brains, and damage to the nervous and circulatory systems. These health hazards stem from inhalation, direct contact with pollutants, and exposure to hazardous substances present in electronic devices, such as lead, cadmium, chromium, and flame-retardant plastics (Shahabuddin *et al.*, 2023).

In developing countries (DCs), managing electronic waste (e-waste) poses significant environmental challenges due to a lack of recycling expertise and technology (Rochman, Ashton and Wiharjo, 2017). Studies conducted in Ghana have revealed prevalent health issues among informal e-waste workers, including respiratory and gastrointestinal illnesses (Amankwah-Amoah, 2016). Additionally, the aftermath of Zimbabwe's financial crisis led to a preference for importing inexpensive substitute electronic and electrical equipment (EEE) from developed nations (Chitotombe, 2013). Improper monitoring, handling, and recycling of e-waste can result in the release of toxic chemicals into the environment, leading to severe consequences for public health (Borthakur and Govind, 2019).

To address these challenges, there is a call for educating informal e-waste handlers about the risks and environmental impacts associated with their activities, with the hope of improving their e-waste management practices (Debnath, Roychoudhuri and Ghosh, 2016; Nwagwu and Okuneye, 2016). For instance, the University of Duhok in Iraq has seen a significant improvement in e-waste management by integrating e-waste awareness and management principles into their curriculum to promote environmental sustainability (Arif and Afroz, 2014). However, in DCs, limited understanding of EEE waste remains a significant barrier, as users often hold onto equipment due to its perceived value or out of ignorance about the harmful components of e-waste (Ghimire and Ariya, 2020). Furthermore, many organizations lack a proper disposal strategy for e-waste (Nwagwu and Okuneye, 2016). Moreover, inadequate disposal facilities and a lack of awareness about the importance of separate e-waste disposal contribute to improper waste management practices among the general population in DCs.

Rwanda's rapid expansion of information and communication technology infrastructure is projected to lead to a substantial rise in electronic waste (e-waste) in the forthcoming years (Nsanzamahoro, Muhammad and Maryono, 2023). For instance, mobile phone usage in Rwanda soared from 0.0046% in 2000 to 56.8% in 2013, ranking the country second in Africa for its annual growth rate of mobile telephone penetration in 2010 (Rutebuka et al., 2015). A survey conducted from November 2014 to January 2015 revealed a fivefold increase in the import of ICT equipment between 2010 and 2014. Rwanda currently has an annual e-waste production capacity of 9,417 tons, with 81.52% contributed by individuals, 12.14% by public organizations, and 6.34% by private organizations (Twagirayezu *et al.*, 2021). Moreover, the trend of generating and handling e-waste in Rwanda is on the rise, with an estimated annual increase rate of approximately 5.95% in EEE imports.

Despite these challenges, Rwanda has taken steps to improve e-waste management, including the establishment of a formal e-waste processing and recycling facility capable of handling over 7,000 tons of EEE, funded by FONERWA. This initiative involves the creation of policies and private investments to support e-waste recycling. Additionally, government bodies such as RURA, REMA, and RSB play crucial roles in providing licensing, supervision, and assistance in various areas, including cross-border deliveries and monitoring, and setting standards (Twagirayezu *et al.*, 2021). However, the informal sector has been so long time existing in Rwanda. However, it is greatly characterized by improper practices like inappropriate disposal, lack of measure to reduce exposure to e-wastes, less awareness/ knowledge about legislation about e-wastes, for instance 84% of repairers/ refurbishers are not aware of legislation governing e-wastes in Rwanda (Revocatte *et al.*, 2020; Kabera, Nishimwe and Mukurarinda, 2023a; Nsanzamahoro, Muhammad and Maryono, 2023). This Necessitate the need of studies examining skills developments approaches for improving e-waste management is essential for informal worker. Hence The overall aim of this study is to assess the different approaches to develop skills concerning e-waste management among informal workers. in Kigali City. This will help to establish and strengthen skills development approaches tailored to informal repairers, which can help to empower them with knowledge and skills to safely handle e-waste, adopt environmentally friendly repair techniques.

## 2.0 Materials and Methods

### 2.1 Description of the study areas

As this study investigates e-waste management in Kigali, Rwanda's capital, which spans 730 square kilometres. Kigali is divided into 3 administrative districts including Gasabo, Kicukiro, and Nyarugenge—comprising a total of 35 sectors. As per the National Institute of Statistics of Rwanda NISR (2022) census, Kigali has 367,000 private households. The highest number of households is found in Gasabo district, with 175,580 households, followed by Kicukiro with 98,883 households and Nyarugenge with 92,537 households. Mobile phone ownership is widespread in Kigali, with 91% of households owning a cell phone, significantly higher than the national average of 71% (Risa, 2022). The use of electrical and electronic equipment (EEE) has expanded in Rwanda as a result of government programs aimed at improving access to electricity and developing the country's ICT (information and communication technology) infrastructure.

### 2.2 Research method

A quantitative methods approach was used in Kigali City to collect data for the study, using quantitative research techniques. A questionnaire was developed and pretested for this study before being given to participants and it was administered by researcher. Topic of questionnaire includes Demographic Information, Knowledge and Awareness about E-wastes, best practices while handling E-wastes and available and accessible education means to informal repairers. The study's target population of this study encompasses individuals and businesses operating within the informal sector, characterized by economic activities conducted outside the formal regulatory framework. This sector comprises a diverse range of activities, small-scale repair services, freelance work, and unregistered businesses, among others. Despite its significance in many economies, estimating the size or scope of the informal sector presents a considerable challenge due to the lack of systematic documentation and official records. Given the population was not organized with unknown population size, the researchers employed a non-probability sampling approach, such as convenience sampling or purposive sampling, to select participants or units for this study. These sampling techniques are often used when it's difficult or impossible to obtain a complete list of the population or when the population lacks clear boundaries (Latpate *et al.*, 2021). Eighty (80) informal repairers in total voluntarily participated in this study.

### 2.3 Data analysis

Both descriptive statistics and correlation analysis were carried out using SPSS Statistic version 27.0. Descriptive statistics was used to describe the different skills development approaches such as Experience, Public Awareness Campaigns, P2P, Training, Online Resources, Informational Materials, School Curriculum, and e-wastes management practices among informal repairers/ refurbishers in Kigali City. A Pearson correlation analysis was employed to assess the strength and proximity of the relationship between independent variable (specifically, skills development approaches related to e-waste management) and the dependent variable (current proper e-waste practices) among informal repairers/ refurbishers of EEE in Kigali City. This analysis aims to determine how closely the skills development approaches are associated with the adoption of proper e-waste practices by the repairers/ refurbishers. Moreover, was employed at conventional confidence level of 95%, which is equivalent to a significance level (p-value) of 5%. This indicates that if a correlation's p-value was less than 0.05, it was deemed statistically significant.

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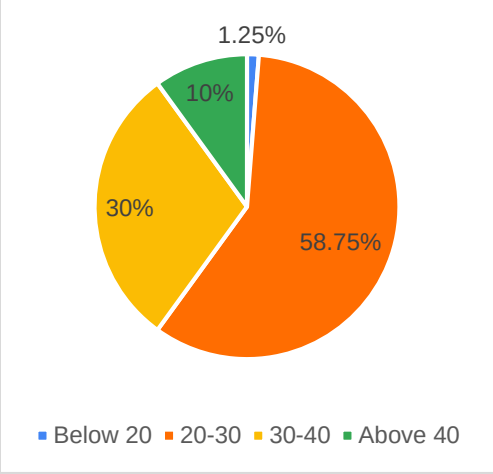
## 3.0 Results and Discussions

During the survey, the repairers/ refurbishers with at least one year in operation was approached and the findings shown that most of respondents are youth between age of 20 to 30 where they account 58.75% while the 30-40 account 30% (Figure 2). Most of respondents are male where they account 97.5% which is reflecting significant gap within this sector where females are few and do not like to engage in activities of techniques/tech. Also, while accessing the knowledge and awareness is quite critical to assess and understand the academic background of respondent, so for this study most of respondents have Secondary level (A2) 55%, University degree (A0) 20%, Ordinally level with 15% and 8 have advanced diploma (A1) 10% (Figure 3). Also, the researcher asked the how and where they were trained for repair of EEE; 30% learned from Secondary school, University and Integrated Polytechnic Regional Colleges (IPRC) are 15% and 10% respectively, Training 5%, 15% learned from other technicians at field and short courses account for 15% (Figure 4).




**Source: Own Elaboration**

**Figure 2: Age category of respondents**

**Source: Own Elaboration**

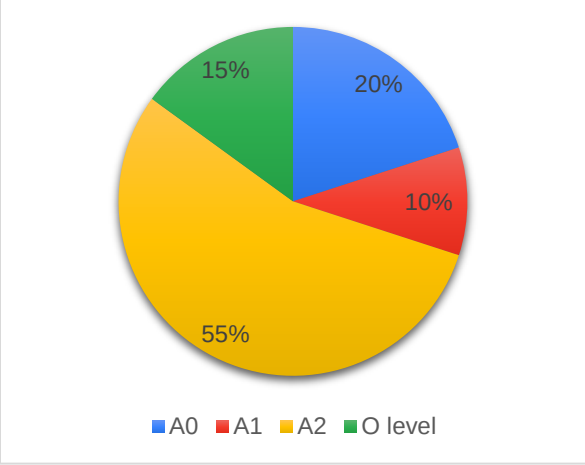



**Figure 3: Respondents Education Background**

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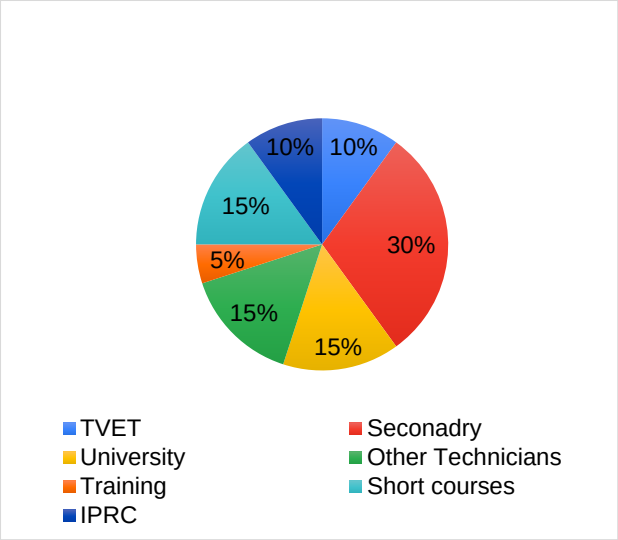


**Figure 4: How technicians learned repair and refurbishment**
**Source: Own Elaboration**

**Familiarity with E-waste management and Effects of E-wastes management**

The results depict that only 40% of respondents has found to have idea about E-waste management. 76% have declared they have idea about effects of e-wastes to environment soil contamination account 55%, air pollution 65 and 35% for Water pollution. However, when it comes to air pollution most of technicians claim there are the effects when they are burned (Table 1). Also, 75% of respondents have idea about the effects of e-wastes to health 50% reported lead to respirator problems, 40% reported injuries, etc. refer to Table 2.

**Table 1: Environmental effects of e-wastes known by respondents**

| Response | Respondents | percentage |
|---|---|---|
| Soil Contamination | 44 | 55 |
| Air Pollution | 52 | 65 |
| Water Pollution | 28 | 35 |

**Source: Own Elaboration**

**Table *2:* Responses for known Health effects of e-wastes**

| Health effects | Respondents | Percentage |
|---|---|---|
| Respiratory Problems | 40 | 50 |
| Skin Disorders | 4 | 5 |
| Cardiovascular Diseases | 4 | 5 |
| Neurological Disorders | 8 | 10 |
| Cancer | 16 | 20 |
| Injury | 32 | 40 |
| Accidents | 8 | 10 |
| Eye Problems | 8 | 10 |

**Source: Own Elaboration**

**The measure to handle e-wastes properly and disposal E-wastes**

Respondents asked if there are measures in place to prevent directed contact or inhaling e-wasted and mainly 50% reported they use gloves and 30% uses masks, etc. refer to (Table 3). However, even if repairers or the technicians reported this measure, it very rare to find someone is implementing and when asked why they do not they reply they do it for specific equipment/task

which is centrally to safe measures. About e-wastes disposal 70% dispose to solid wastes collector, resell are 50%, storage 30% and 35% to formal e-wastes collector (Table 4).

**Table 3: Responses about measure to handle e-wastes properly**

| Responses | Respondents | Percentages |
|---|---|---|
| Gloves | 40 | 50 |
| Masks or Respirators | 24 | 30 |
| Coveralls or Protective Clothing | 12 | 15 |
| Safety Shoes or Boots | 12 | 15 |
| Aprons or Smocks | 12 | 15 |
| Head Protection | 4 | 5 |
| Hand Hygiene | 12 | 15 |

Source: Own Elaboration

**Table 4: Responses about E-wastes disposal methods available to field**

| Responses | Respondents | Percentages |
|---|---|---|
| Solid wastes collector | 56 | 70 |
| Resell | 40 | 50 |
| Storage | 24 | 30 |
| Formal e-wastes collector | 28 | 35 |

**Source: Own Elaboration**

### Different skills development approaches available to e-wastes informal sector

Different methods have been identified to raise the knowledge of repairers mainly 35 % has found to fetch e-wastes aspect online, School curriculum 30%, 25% trainings, 15% from information materials, 4% from public campaigns, and 4% learned by Experiences (Table 5).

**Table 5: Different learning methods available to e-wastes informal sector**

| Responses | Respondents | Percentages |
|---|---|---|
| Public Awareness Campaigns | 4 | 5 |
| Informational Materials | 12 | 15 |
| Online Resources | 28 | 35 |
| School Curriculum | 24 | 30 |
| P2P | 8 | 10 |
| None | 20 | 25 |
| Training | 20 | 25 |
| Experience | 4 | 5 |

**Source: Own Elaboration**

### Relationship between the existing skills development approaches and E-waste management practices

The correlation method, a statistical technique used to measure the relationship between variables, was employed in this study. Simply put, if the correlation value is positive, the relationship between variables is considered positive, and vice versa. Following this, the next step is to determine whether the correlation is statistically significant. The results from table 6 indicate that there is significant high positive skills development and e-wastes management among the informal sector of Kigali City at ($r=0.684$, $p\text{-value}=0.001<0.01$). This implies that an increase of access to



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different means of skills development leads to the proper e-wastes management practices among informal sector of Kigali City. Additionally, statistically significant relationships between the dependent and independent variables from the model were considered significant at a 5% level of significance.

**Table 6: Pearson Correlation Coefficient**

| | | X1 | X2 |
|---|---|---|---|
| Skills development approaches (X1) | Pearson Correlation | 1 | |
| E-wastes management practices (X2) | Pearson Correlation | 0.684 | 1 |
| | Sig. (2-tailed) | 0.001 | 0.001 |

**Source: Own Elaboration**

**Discussions**

It is obvious that e-wastes are global challenge which need proper management (Mihai and Gnoni, 2016). There several barriers have been found to hinder proper e-wastes management which include lack of Awareness environmental and health hazards associated with improper e-waste disposal and this match with the finding of this research less than a half are aware of term e-waste management (40%) which is similar with study conducted in Addis Ababa, Ethiopia which reported 92% of dismantlers, 70% of sellers, and 55% of repair and maintenance workers exhibit poor awareness levels (Gollakota, Gautam and Shu, 2020). This lack of awareness and knowledge lead to irresponsible disposal practices, such as throwing electronic devices in general waste bins (McAllister, 2015). So, the nexus between e-waste management practices/knowledge and the educational resources accessible to informal repairers is paramount. An analysis of this relationship reveals a significant shortfall in educational avenues tailored to informal repairers, consequently leading to substandard practices in e-waste management. Most improper disposal of e-wastes are existing, 70% dispose their wastes together with other solid wastes and 35% only identified at least disposing some of their e-wastes to formal e-wastes collectors (table which is the same to Addis Ababa in Ethiopia as reported by (Gollakota, Gautam and Shu, 2020), where in study group found unsafe disposal (50%), unsafe storage (36%), and transfer (14%) to other users. The similar situation in Maseru, Lesotho as reported by (Masoabi, 2020). Approximately 88% of respondents indicated that they were willing for recycling but not willing to pay the recycling fee. E-waste management practices established were the storage of e-waste in the households and disposal to the landfill together with general waste. Where e-waste was disposed of, practices were generally poor, with the majority of e-waste being disposed to own dumps, dump sites or end up being burned.

The skills development approaches explored and are in application among repairers most of them tend to be uneasy to monitor and ensure they are accessed effectively as they self-directed including use of Online resources, P2P, information materials etc. Also mean like School curriculum has one big advantage that it can provide deep foundation however it encounters one big drawback of being non-recurring which may lead the learner forget or time by time become less concerned. Also, there are respondents responded that they are trained by government agencies in partnership with local NGOs and waste collection/recycling company called Enviroserve which illustrate the role and necessity of collaboration among stakeholder in e-wastes management (Jahnsen *et al.*, 2023). This may find as the best options however they reported some of its shortfalls include short time in implementation and less frequency in span of time.

By analysing the results from this study most of respondents has found to have very little information to different aspects of e-wastes management. For instance, respondents were asked about health effects of e-wastes and most of them tended to respond by outlining only one effect while it is known that they are several. This is not contrary to the situation in India in Musheerabad area, it was found that approximately 72% of those responsible for handling electronic waste were



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unaware of its significance, and 71% lacked knowledge about the health hazards linked to it. Furthermore, 85% did not employ any protective equipment. Although 16% recognized health problems resulting from improper e-waste management, 77% believed their handling methods were adequate. Most owners of e-waste processing centers perceived informal handling practices as not posing health risks. Additionally, they noted a lack of awareness campaigns conducted by any agency (Mishra, Shamanna and Kannan, 2017). In Rwanda there had found poor and improper practices not only in this study also in research conducted by Kabera et al., (2023) reported that only 10 out of 64 of respondents asked about their awareness about e-waste legislation has known about it, indicating the lack of awareness and knowledge. Here in research aimed to identify the learning means as tools to raise the awareness and knowledge which are essential drivers of proper e-waste management, shaping individual behaviours, influencing policy decisions, empowering communities, and building capacity among stakeholders. By promoting a deeper understanding of the environmental, social, and economic implications of e-waste, are helpful to work towards more sustainable and responsible approaches to managing electronic waste (Ofori and Opoku Mensah, 2022).

Testing the knowledge and knowledge is subjective and sometime require subjective approaches also researcher acquire some of qualitative information, most repairers refer the environmental effects like air pollution only when e-wastes are burned. However, this is not enough as the effects of e-wastes range from indoor workshop environmental quality to planetary (Ming, 2023). Also, by referring to Table 6 indicates that there is significant high positive correlation between skills development and e-wastes management among the informal sector of Kigali City at ($r=0.684$, p-value=0.001<0.01). This implies that an increase of access to different means of skills development leads to the proper e-wastes management practices among informal sector of Kigali City. This is confirmatory to most research indicating the relationship between the knowledge and understanding to e-wastes management and practices; for instance Ali & Akalu (2022) in their study about E-wastes awareness and management in Addis Ababa Ethiopia found that The awareness level of the respondents is strongly associated with the newness of the issue ($V = 0.64$) and lack of concern ($V = 0.44$), and moderately associated with educational status ($V = 0.31$), their lack of access to information (0.31). Hence this emphasizes the great influence of having enhanced skills development to raise e-waste awareness and skills about proper e-waste management (Han, 2018; PR & Narula, 2018).

## 4.0 Conclusion

The study has shed light on the available learning means concerning e-waste management and its implications for informal e-waste repairers and refurbishers. Through an exploration of various educational resources and training opportunities, it has become evident that while there are some initiatives in place, there remains a significant gap in tailored education and support for those working in informal sectors. The study outcomes indicated that 60% was not familiar with e-wastes management, 95% know some of effects of e-wastes to environment where 55, 65 and 35% respondent soil contamination, air pollution and water pollution respectively. Regarding to health effects of e-wastes 75% responded they are aware that e-wastes have effect to human health, mainly respiratory problems and injuries had engaged in their answer with percentage of 50 and 40% respectively. However, when comes to measure to avoid effects from their direct exposure to e-wastes there is no observed measures to lessen these risks. Different learning means were found among the informal repairers/ refurbishers, most of them were informational materials with 35%, Online resources with 30% and trainings with 25% while 25% responded none of any means to learn about e-wastes also by results there is significant high positive correlation between skills development and e-wastes management among the informal sector of Kigali City at ($r=0.684$, p-value<0.001). The industry encounters various obstacles, such as workplace dangers, environmental contamination, and health hazards linked to the mishandling of electronic waste. Nonetheless, there's a rising acknowledgment of the importance of empowering and supporting informal workers through specialized educational schemes and efforts to enhance their



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capabilities. By furnishing them with the necessary information, expertise, and support, there's potential to boost their ability to handle e-waste in a responsible and sustainable manner.

## 5.0 Recommendations

According to the findings and situation found on field there following are the recommendations to enhance the e-wastes management especially in the terms teaching and raising the awareness and knowledge:

- Develop specialized training programs specifically designed for informal e-waste repairers and refurbishers. These programs should cover various aspects of es-waste management, including safe handling practices, recycling techniques, and environmental regulations.
- Organizing informal sector in e-waste repair and refurbishing to foster partnerships between government agencies, non-profit organizations, academia, and industry stakeholders to support educational initiatives for informal workers of e-wastes. Collaboration can help leverage resources and expertise to develop comprehensive training modules and outreach programs.
- Ensure that educational materials and resources are easily accessible to informal workers, considering factors such as language, literacy levels, and technological infrastructure. Utilize multimedia formats, including videos, infographics, and interactive online platforms, to enhance engagement and comprehension.
- Involve local communities and grassroots organizations in the design and delivery of educational interventions. Tailor outreach efforts to address the specific needs and priorities of different communities, taking into account cultural norms and socioeconomic factors.
- Advocate for the recognition and formalization of informal e-waste management activities, including the provision of legal protections and social benefits for workers. Formalization can help improve working conditions, promote environmental stewardship, and integrate informal workers into formal waste management systems.
- Implement mechanisms for monitoring and evaluating the effectiveness of educational programs over time. Collect feedback from participants and stakeholders to identify areas for improvement and refine strategies for long-term impact.
- Future research (es) must deeply evaluate effectiveness of e-wastes skills development approaches, analysis of current stakeholders' engagement to improve e-waste management in informal sector, analysis of adequacy of legislation frameworks and identify gaps in their enforcement.

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