

Working conditions and environmental exposures among electronic waste workers in Ghana

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Objective: To investigate and describe informal e-waste recycling and working conditions at Agbogbloshie, Accra, Ghana.

Methods: We conducted in-depth interviews which were qualitatively analysed from a grounded theory perspective.

Results: Workers obtained e-waste from the various residential areas in Accra, then dismantled and burned them in open air to recover copper, aluminum, steel, and other products for sale to customers on-site or at the nearby Agbogbloshie market. The processors worked under unhealthy conditions often surrounded by refuse and human excreta without any form of protective gear and were thus exposed to frequent burns, cuts, and inhalation of highly contaminated fumes. We observed no form of social security/support system for the workers, who formed informal associations to support one another in times of difficulty.

Conclusions: e-waste recycling working conditions were very challenging and presented serious hazards to worker health and wellbeing. Formalizing the e-waste processing activities requires developing a framework of sustainable financial and social security for the e-waste workers, including adoption of low-cost, socially acceptable, easy-to-operate, and cleaner technologies that would safeguard the health of the workers and the general public.

Keywords: Accra, Agbogbloshie, Environmental exposures, Environmental toxins, e-wastes, Informal recycling, Occupational health, Typology, Waste picking, Waste scavenger

Introduction

Information and communication technologies have assumed a central place in modern life. However, there is an unfortunate technology gap between developed and developing countries, raising fears that the “digital divide” could exacerbate existing global development disparities.^{1–4} In many developing countries, the demand for computer technology has largely been met through the importation and shipment of used electronic products,⁴ leading to a huge increase in electrical and electronic waste materials in those nations’ waste stream.^{5–7}

Many studies conducted in China, South East Asia, Latin America, and the Caribbean have shown that where electronic waste exists, informal recycling activities are performed under dangerous conditions. Informal workers themselves face discrimination, stigmatization, emotional vulnerability, and social

inequities, including social exclusion.^{8–14} In Latin American countries; especially in Argentina, Mexico, and Brazil, the social exclusion of the informal level workers has presented obstacles to efforts meant to formalize e-waste activities.^{10,11,13–15} Additionally, the lack of social protection for the informal e-waste workers has led to perceived public disdain towards e-waste workers.

In Ghana, the widespread inability to afford new electronic products, coupled with the quest to keep pace with the global advancement in electronic technology, has led to massive importation of mostly second-hand electronic gadgets from developed countries, mostly in Europe and North America.^{3,6,7,16,17}

While the Ghanaian government does not forbid the importation of second-hand electronic and electrical products, it is party to the Basel Convention on transboundary movement of hazardous wastes, and therefore outlaws the importation of any form of waste product.¹⁸ However, contrary to the prohibition, large quantities of waste products still find entry

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into the country under the guise of second-hand electronic and electrical products.^{6,7,18} In 2009, a Ghana government report revealed that out of around 215 000 tons of electronic goods imported into the country, 15% could be classified as waste,^{17–19} In addition, many imported electronic products are close to the end of their lifespan,¹⁶ and quickly became obsolete, thereby increasing the amount of e-waste in the general waste stream.^{6,7}

Ghana's e-waste dump at Agbogbloshie is reportedly the biggest in sub-Saharan Africa and has attracted the attention of many international environmental groups, researchers, and journalists.²⁰ The dump is currently a site for trade in products recovered from the waste stream.^{17,18,20} Informal workers scavenge the waste, dismantling the scrap in open-air burning to recover precious components for sale, including gold, copper, silver, aluminum, iron, and brass.¹⁶ The livelihood of many people depends on the income generated from these activities.^{18,21–24} However, this work can be dangerous. Studies conducted at the dumpsite indicated high levels of lead, cadmium, and chromium in the soil. Some of these contaminants were over 50 times higher than maximum exposure levels established by the World Health Organization.^{16,17,19,25} Unexpectedly, high mean levels and ranges of polybrominated diphenyl ethers (4.5; 0.86–18 ng/g lw) and polychlorinated biphenyls (62; 15–160 ng/g lw) in breast milk of mothers in Ghana are reportedly linked to unsafe handling and inappropriate management of e-waste in the country.^{18,21,22,25}

There is a lack of reliable data on the processes involved in e-waste recycling and on the working conditions of e-waste workers at Agbogbloshie.^{18,25} The lack of empirical data on informal sector working conditions in Ghana poses a challenge to attempts by policy makers to design effective e-waste management strategies, and frustrates the plans of industries intending to make rational investment in the sector.^{18,20} This study was therefore conducted to address the existing data gap and to contribute to the limited literature on e-waste workers and their activities and working conditions at the largest e-waste dumpsite in sub-Saharan Africa. An analysis of the empirical data will provide a deeper understanding of the activities of the e-waste workers, including direct and indirect threats, opportunities as well as social organization and power relations among the workers.

Methods

Design and participants

A qualitative study was conducted during the months of May and June 2012 with e-waste workers at Agbogbloshie dumpsite. Twenty e-waste workers were selected to participate in the study. The recruitment

criterion was workers who had at least one year continuous experience in e-waste processing. This criterion was based on preliminary studies on migrants at the Agbogbloshie dumpsite which showed that the e-waste workers were mostly migrants from northern Ghana who took between 6 and 12 months to adjust to life at the dumpsite and to establish independent e-waste picking activities.^{26–28} Interviewers contacted e-waste workers, read, and explained participant information sheets. Workers agreeing to participate signed or thumb printed the consent forms. Ethical clearance was sought from the Ghana Health Service Ethical Review Board.

Data were collected through in-depth, open-ended interviews. The in-depth interviews were conducted and recorded in Dagbani in a secluded environment so as to avoid interruptions by other people. The interviews were conducted in person, with two interviewers and a participant. The interviews focused on issues such e-waste scavenging activities, recycling methods, and working conditions. Theme saturation — a point where new data collected no longer brought additional insights to the stated objectives — was reached after the twentieth in-depth interview. At this point, the interviews were discontinued.²⁹ All the in-depth interviews were audio-recorded and field notes taken by two expert interviewers who were native Dagomba and fluent in both Dagbani and English.

Analysis

The two expert interviewers expanded the interview notes and separately transcribed and translated verbatim all the interviews into English in a word processing application. In a situation where there was no consensus, the interviewers reviewed the transcriptions and the original recordings until consensus was reached. The transcripts and expanded notes were stored as files and coded manually for textual analysis in accordance with the principles of grounded theory,^{29,30} since we sought to generate a theory rather than testing a hypothesis. Specifically, the coding process involved identifying major themes and sub themes in each of the transcripts. The themes were compared across the transcripts to obtain a comprehensive view of the working conditions and determine differences and similarities in the e-waste scavenging activities, recycling methods, and working conditions of the e-waste workers. The themes were illustrated with verbatim quotes and interpreted in the light of extant literature.

Findings

Participants' characteristics

A total of 20 e-waste workers took part in the study with refusal rate less than 5%. All of them came from the Northern Region of Ghana and belonged to the Dagomba ethnic group. They were all male, aged

13–34 years, with the majority in their 20s. Of the 20 participants, only five had junior high school education; the rest had received only primary level schooling or no formal education at all.

Skill levels, Recruitment, and Training of e-waste Processors

Upheaval in the Northern Region of Ghana following ethnic conflicts and chieftaincy disputes in early 1990 and in 2001 had forced many citizens in that region to flee and seek refuge in the commercial and urban centers in southern Ghana.^{26,28,31} These internally displaced refugees who were mostly without employable skills were compelled to go into wastes picking and scavenging for livelihood and survival.^{18,20,31} However, following the return of peace in the place of origin, the migrants had returned home much better off economically than their peers who remained in the conflict zone.^{26–28,32} They had made colossal savings through waste picking and scrap sales which triggered a new phenomenon, a mass migration of young low-skill and unskilled adults to relatively more developed southern coastal towns and cities to engage in waste picking.^{26–28,32}

For these recent migrant, the decision to go into the e-waste trade was made voluntarily as a means of livelihood and survival.^{26,27} Most of them learned about the e-waste trade through social networks, mostly through friends and relatives who had earlier been engaged in the e-waste business. Upon arrival at the dumpsite, the new workers studied their more senior friends and relatives for a brief period in order to acquire the required skills for the trade. One of the e-waste workers skilled in e-waste burning explained how he went into the trade, “I followed my senior brother to learn about how to do the job. I am yet to be perfect.” The new workers referred to these friends and relatives they studied as “masters.” The new entrants in the e-waste business reported their own role as apprentices or trainees, following their masters on a daily basis for 6–12 months until they became proficient and began to work independently. “I came to this my brother here who made me to work with him until I left and started working with a different person. Now I work alone.”

Other waste pickers reported that they went into the job without training or working under anybody. These respondents merely observed how others went about the work and eventually started their own operations. “I got to know of the job after I came to Accra, I observed and got to learn how to do the job so I don’t have a master except a computer master who teaches me certain parts of the computer that may be relevant.”

Processes Involved in e-waste Recycling Sources of raw materials

On a typical working day, the e-waste workers known as scavengers formed pairs for the purpose of raw

material collection. They trekked to residential areas and communal transit stations with human-drawn-cart or pushcart to collect electronic wastes and other metallic scraps from homes. This was described by one of the e-waste workers who said: “I push truck to some suburbs in Accra to collect e-waste.” The e-wastes that they collected often include damaged and faulty computers, television sets, and refrigerators, which their original owners were willing to discard or give away for token fees. The prices at which the scavengers bought these gadgets were very low since their owners considered them to be of no further value. The scavengers transported the discards to Agbogbloshie waste dumpsite. Sometimes, the scavengers tested some of the gadgets at electronic repair shops to find out if they were still functioning and could be kept for personal use or for re-sale at higher prices. The scavengers travelled in pairs from house-to-house or from one communal dumpsite to the other in search of waste materials.

Waste pickers usually sold the products to e-waste buyers and dismantlers for processing. When scavengers did not have enough money to go to the communities to collect waste, buyers would lend them money to do so at zero interest rates. This was reported by one of the e-waste buyers as follows: “I sit here and wait to buy from those who get the electronic waste from various parts of Accra. Sometimes, when they are going to hunt for the computers and they don’t have enough money I give them some money.” Some of the e-waste buyers rode on motorbikes to meet the scavengers at designated locations in the communities to negotiate or bargain with the waste pickers for acceptable price of the materials even before the pickers arrive at the recycling site. This point was captured in the words of one e-waste buyer as follows: “I buy the e-waste from the boys who go to the various suburbs in Accra with truck.” “I go to meet those who go and buy computers from several parts of Accra. I negotiate and buy from them”

Methods of processing e-waste

The main processing methods were manual dismantling and open-air burning. The dismantling was done to remove vital components such as the mouse, power pack, wires, motherboard, keyboard, hard disk, and transistors. Those components that were not functioning but contained valuable materials like copper and aluminum were sent for burning. The dismantling of the gadgets was done using tools such as hammers, screwdrivers and cutters. The Phillips-head screw driver, which the e-waste workers popularly referred to as “star,” was used to unscrew the computer cover to remove useful components. Indeed, the e-waste processing was reported to be largely manual and



Figure 1 Copper cables ready for burning.

enormous mechanical force was sometimes applied to physically remove the metallic parts from the copper wires and plastic covers. When a dismantler was asked how he had performed the dismantling task, he said, “I will dismantle it with tools such as hammer and screw drivers to remove the parts that I need. The copper is covered by rubber but aluminum is not covered by rubber. The rubber covering the copper is burnt off in order to extract it from the waste’ (Fig. 1).

As described by that worker, the final major activity undertaken by the e-waste workers to recover valuable components was burning. They burned the e-wastes to extract copper. Burning activities were generally undertaken at a small distance from where the dismantling, weighing, and selling of the e-waste products took place, due to the toxic smoke generated during the burning process. Those who did the burning received the materials to be burnt from dismantlers through assistants, commonly referred to as “boys.” One of the workers who did the burning had this to say: “Usually we sit here and wait for the extractors/buyers of electronic waste to bring their copper for burning.’ ‘We don’t have to go there for the copper to burn. They, the dismantlers I mean, will bring it to this site themselves.” The smoke generated from the burning process is visible indication of air pollution (Fig. 2).

Disposal of unwanted fractions

During the dismantling and burning stages of the e-waste recycling processes, some amount of waste was still generated. The waste generated was always left at the site by the e-waste workers – sometimes close to the nearby Korle Lagoon or thrown into the lagoon as one of the workers had this to say: “I discarded the other parts of the computer I don’t want over there [open dump] where the rubbish are normally left.”

Marketing of recovered products

e-waste workers sold the recovered products to customers at the site or in the nearby Agbogbloshie market. The clientele or customers for the recovered



Figure 2 Smoke from e-wastes burning.

products were mostly artisans from Nigeria. The prices of the recovered products (copper, aluminum, and steel) depended on the weight of the recovered products, which were weighed before sale as one of the e-waste workers reported: “We have buyers at this place who will weigh your material and they will buy your equivalent price.” The prices at which the recovered products were sold were determined by intermediaries who in turn sold the recovered products to steel smelter factories situated in Tema, Ghana’s main industrial center, where the recovered products were re-fabricated into new products.

Safety of working environment

The working conditions of the e-waste workers were studied, including safety of working environment, personal protection against hazards, economic benefits, welfare of workers/social support, working hours and days, and housing. The majority of the e-waste workers sat and worked near a heavily polluted drain, which emptied into the Korle Lagoon. The unwanted fractions of the e-waste were often dumped into this drain. Other refuse generated was left at the site and sometimes washed by storm water into the drain. Pollution has resulted in the gradual death of the lagoon, which is now stagnant and a constant source of foul smell in the area. The stench from the drains and lagoon presented a perpetual nuisance at the dumpsite. In spite of this chronic nuisance, e-waste workers reported that they were accustomed to these conditions, as articulated by one of the workers there: “...the deteriorated environment here is not a challenge because I am used to it.” The e-waste workers had divided opinions about the insanitary conditions under which they worked. A few of them felt the situation was bad and needed attention (quoting one of the workers: “The dirt and the bad water here is disturbing, we are not really doing enough to make this place clean”). The majority felt that the place should remain in squalor, otherwise they risked losing the land to the city authorities who would sell it and

thereby deprive them of their livelihoods: “Now AMA (Accra Metropolitan Authority) is selling the land, if we keep the place neat AMA will come and sell the place and we will have no place to work.”

Personal protection against hazards

The e-waste workers did not use any form of protective devices, as reported by one of them as follows: “I don’t rely on safety equipment when I am burning electronic waste except some heavy shoes which protect me from the fire.” Apart from heavy shoes that few of the workers wore, the rest did not use anything to protect themselves from the hazards as one respondent echoed (Fig. 3): “I use heavy shoes to protect me from cuts in my legs, I don’t use gloves, but what I do is I don’t get close to where they do the burning and in case am passing by I use duster to cover my face, nose and eyes.” There were many reports of frequent burns and cuts to the hands of e-waste workers as emphasized by one of the e-waste workers, “I admit the work affects me. I hope you see the cuts on my palm, they are indeed from the job.”

Economic benefits

The amount of money an e-waste worker earned varied widely by activity undertaken. The study revealed that scavengers and e-waste buyers/dismantlers earned more money per day than those who did the burning. While on a good day a scavenger and dismantler could make USD26.00 and USD52.00, respectively, those who did the burning made only USD16.00. The daily incomes varied widely by day and were irregular to the extent that the e-waste workers sometimes even went home without any money as reported by one of the workers: “I make about USD16.00 a day. Other times too I get nothing,” “I can make USD26.00/day and am satisfied with it because I am able to spend some and save the rest.” “I earned about USD52.00/day, sometimes less. Other times I get nothing.” Most of the e-waste workers were not satisfied with the situation and intended to return home to start more formal businesses after raising sufficient capital. The waste burners were the worst-off economically as this activity did not pay much as evident from the narrative of one of the respondents: “We sit here and burn the materials for those who go to collect them and they pay us. But the pay is small making us to sometimes go into terms with the boys who bring their masters’ copper; we let them give us part of the copper or aluminum. After selling we give them their share. Their masters usually wouldn’t get to know.”

Welfare of workers/social support

Although electronic waste recycling at Agbogbloshie is informal and therefore workers do not receive state or employer benefits, some of the workers came together to form unregulated informal associations. These are usually based on worker ethnic groups/



Figure 3 e-wastes burning without protective devices.

places of origin and not on the basis of work activity. Some of the associations in operation in the area were Nanton Youth Association, Gushegu Association, Savelugu Association, Bipala lan’gu Association, and Tolon/Kumbungu District Association. Membership in these associations was completely voluntary. The benefits derived from the associations were generally limited to financial and moral support in times of important social events. As one worker stated: “I belong to Nanton Youth Association. The association supports members when they are getting married or having a naming ceremony, also when a member is bereaved, they support.”

None of the e-waste workers contributed towards social security or ever insured their businesses against burglary and/or fire outbreaks. The only form of social security or social support was the help they received from the informal associations in times of difficulties or need.

Working hours and days

The number of daily working hours reported was similar for all the participants interviewed. The average length of workday was between 10 and 12 hours per day. Scavengers usually started the day’s work as early as 5:00 a.m. and closed at about 5:00 p.m.. Buyers/dismantlers started their work at 6:00 a.m. and closed at about 5:00 p.m., whereas burn workers started work at about 6:00 a.m. and closed around 5:00 p.m. The number of days a person worked in a week depended on the individual. Some worked throughout the week, while others worked for 6 or 5 days per week. Those who preferred to take days off usually did so on Sundays and Fridays. Participants were mostly Muslims and therefore, Fridays were important worship days. However, a majority of the workers worked continuously throughout the week without rest unless they were taken ill.

Accommodation

Two different types of living quarters were reported by participants. A majority passed the night with

friends and relatives in wooden structures or kiosks at the neighbouring Komkomba market, which was situated very close to where they worked. In most cases, the kiosks in which they spent their nights belonged to other waste pickers. A few workers with families lived with spouses and/or children in rented single rooms in nearby suburbs of Accra.

Discussion

Our results are consistent with that of Wilson and co-workers,³³ who reported that waste scavenging and waste picking for income generation were mostly carried out by the poor and marginalized social groups in developing countries. The Northern Region from where all the e-waste workers migrated is one of the poorest regions in Ghana.²⁷ The harsh economic conditions, ethnic conflicts, and chieftaincy disputes in the area have likely compelled them to migrate to the capital city on the coast in search of better opportunities.²⁶ Improving the living and economic conditions of the people in this region might help in curtailing the migration of the youth to the large cities south of the country where industrial and commercial activities are widespread and tend to offer employment opportunities.^{26–28}

After arriving in Agbogbloshie, rural migrants went through a time a period of adjustment without work. Reports show that this transitional period varies across the world's geographic regions; there have been reports of shorter transitional periods in China and Southeast Asia.^{12,20,34–37} This transitional period also coincided with period during which the new migrants studied those already engaged in the waste picking activities. This is consistent with findings from studies conducted in Asia and Latin America.^{9,12,14,38} On the whole, the waste pickers we studied had no formal social support and therefore formed informal associations to support each other during difficult social and financial circumstances. One of the natural support strategies adopted was the formation of associations with members contributing to a revolving mutual saving/fund for use in times of economic hardship. Studies conducted in Latin American countries, especially in Argentina and Mexico, observed similar informal associations, which served as social support group for the welfare of the informal waste pickers.³⁹

While Mitchell,¹² reported that both males and females undertook e-waste scavenging in Asia, those found engaged in the e-waste processing activities at Agbogbloshie in Accra were exclusively males. The only women seen at the site were selling food items and sachet water to the workers. When asked why they did not engage in the e-waste picking, female vendors explained that they preferred vending work as it was less physically stressful than e-waste dismantling and burning activities.

The procurement of e-waste at Agbogbloshie was carried out by teams of scavengers. This finding corroborates those of Furedy, Choi and co-workers,^{8,40} who reported that a floating population of private collectors constituted one of the main channels of e-waste collection in Asia. In Ghana, the waste materials were acquired in the communities at token fees, an observation which is quite consistent with similar research reports in Argentina where it has been reported that while some of the pickers acquired the waste materials for free, 6% of them paid for some of the materials gathered in communities.^{14,15} However, unlike the Latin American context, our study identified a new dimension of e-waste scavenging in which the buyers pre-financed the activities of the scavengers at zero interest rates. For buyers, this strategy helped avoid competition from other buyers and served as a collateral security to guarantee constant supply of recovered products. The sources of waste materials in Ghana mirrored those in other developing countries, including India, China and the Latin American countries. Furthermore, studies conducted on informal level waste recycling activities in Argentina and Mexico have shown that solid waste materials were recovered from residential, commercial, and industrial sectors.^{2,10,11} However, while the collection process has been absolutely legal in Ghana, in Buenos Aires, Argentina, the waste picking work has been reported to be explicitly illegal in some cases and in others it was tolerated or even accommodated by municipal authorities.^{15,39} A study conducted by Parizeau,¹⁴ reported that the trade in recyclable materials; depending on the context, was legal and formal at some point between collection and reincorporation into industrial circuits of production in Argentina.

The main recycling methods observed in our study, were manual dismantling and open-air burning of the e-wastes; much the same techniques employed by waste pickers in Latin America.³⁹ These methods did not need highly skilled labour and were, therefore, even ideal for people with low educational backgrounds. The main environmental exposure observed was the smoke from the burning process.^{17,19,25} This smoke has been reported to contain extremely toxic dioxin and furans, pollutants¹³ with serious health effects on both e-waste recyclers and the surrounding populations.^{41–45} In addition to the direct inhalation of smoke and fumes, toxins from the smoke could also contaminate food products sold in the nearby open market and rainwater harvested in the neighbourhood, making their consumption unsafe for humans.^{25,46–49} Heavy metals, such as copper, aluminium, and cadmium released into the air, soil, and water during burning could have health implications for individuals living in the area.^{19,25,41} To mitigate health risks of this nature, Johnson^{17,50} proposed

environmental remediation of hazardous waste sites whereby contaminated soil, chemical hazards, and groundwater as well as surface water could be treated or removed from the waste dumping and processing site. This would help curb any potential human exposure and thereby prevent adverse health effects among persons living in the precincts of the site. However, our opinion is that such an environmental remediation intervention might be too costly for a developing economy and we instead recommend preventive strategies that discourage the development of such contaminated sites in the first place.

The current methods of recycling e-waste at Agboglobhie were largely rudimentary and meant only to recover copper, aluminum and steel. However, e-waste also contains other valuable materials such as indium, palladium and precious metals such as gold and silver, which could be recovered and recycled for other purposes.³⁹ This means that current e-waste recycling methods at Agboglobhie were not efficient for the resource recovery in terms of valuable components. The recyclers, therefore, did not get the full value of the mineral resources as some of them were likely burnt off as airborne oxides.

The e-waste workers worked under appalling conditions, close to an over-abused and grossly polluted drain, which discharged its content into the Korle Lagoon. Additionally, wastes generated from the activities were left at the site together with other domestic wastes and human excreta. These conditions exposed the recyclers to diarrhoeal pathogens, soil-transmitted helminths, and other sanitation related diseases.³⁴

Although the e-waste recyclers were exposed to hazards from smoke and sharp objects, a majority of them did not use personal protective devices. In a similar population in India, Chikharmane and colleagues found that e-waste workers were at a higher risk of work related accidents and were more likely to suffer physical injuries and physical disabilities than the general population.³⁶ A recent review on e-waste and health revealed that informal recyclers at one dumpsite in Mexico City were reported to have a life expectancy of only 39 years compared to a much higher national average life expectancy and that in India, children involved in informal recycling had a 2.5 times higher potential of morbidity than the national average.^{30,39,51} Studies conducted in Latin American countries have classified health threats associated with recovery of materials from waste stream under six (six themes — namely, chemical hazards, pathogen infection, ergonomic and musculoskeletal damage, mechanical trauma, emotional wellbeing, environmental contamination, health, and the cooperative.^{30,39}

Epidemiological studies conducted at e-waste dumpsites in many regions have reported that infants whose parents were living near the e-waste processing site were likely to suffer from congenital malformations such as defects of the heart, neural tube, and cleft palate and other health conditions.^{6,7,17,19,25,38–40,50–56} The supervision of workers' use of protective equipment could be facilitated if the e-waste processing activities were formalized to ensure closer monitoring and enforcement, encourage stronger adherence to safety protocols, and thus provide for minimization in the levels of exposure to these physical hazards.

Furthermore, extensive analyses of income data on e-waste workers and those in informal waste recycling sector in general revealed that waste collectors (scavengers) represented the most vulnerable group in terms of income and that most of them received variable and extremely low incomes ranging from US\$2.3 to 4.6 per day.³⁷ In the case of this current study, the most vulnerable group in terms of income represented those involved in the burning of the e-waste because the burners did not own any materials and depended on what the pickers retrieved from the communities. However, the one thing that was common to all the categories of the e-waste workers was the irregular nature of the daily incomes across the different groups. Consequently, some of those engaged in the burning process were sometimes compelled to enter into bargain agreements with those engaged in dismantling to allow them keep part of the recovered items on compassionate grounds. In terms of hours of work, the participants mostly worked between 10 and 12 hours per day and six days in a week. The 10–12 hours average time spent collecting waste materials per day in Ghana differed from that in Latin America where waste pickers did fewer hours per day at work and spent an average of 6.2 hours per day collecting waste materials.¹⁴

This was found to contravene the Labour Act (2003) of Ghana,⁵⁷ which stipulates a maximum working hours of eight per day and a weekly rest of 48 consecutive hours and evocative of forced labour or labor exploitation. The aggregate long daily working hours has been reported to be associated with negative health effects such as fatigue and workplace accidents and may place additional occupational health burden on the e-waste workers.⁵⁸ Our findings compare with the number of days e-waste pickers worked per week in Argentina where it is reported that they did an average of 5.4 days per week, with a median value of 5.0 days per week.¹⁴

Conclusion

In the urban political economy, e-waste workers tend to occupy the political and economic margins for lack of essential technical skills required in the formal

employment sector. They are therefore among the poorest and the most vulnerable members of the urban populations in Ghana.^{20,37} According to an edited volume commissioned by the German Federal Ministry for Economic Cooperation and Development (GIZ), empirical studies have demonstrated the importance of the informal sector in the economies of developing countries,^{20,37,53,59} in addition to playing a crucial role in environmental protection. For instance, informal employment accounted for 48% of non-agricultural employment in North Africa, 51% in Latin America, 65% in Asia, and 72% in Sub-Saharan Africa in the late 1990s.⁴ Despite the important contribution to society, the informal sector groups are often relegated to the political periphery and hardly take part in any political decisions affecting their welfare, save for the right to vote.^{26,27} On account of their lack of economic independence, they were often exploited by politicians who enticed them with small sums of money in exchange for votes and regrettably to foment troubles during election campaigns in Ghana.^{26,27,32} Our study revealed that the e-waste workers at the Agboghoshie dumpsite in Accra, Ghana, worked in very challenging environment and under very strenuous and hazardous conditions. We therefore conclude that to be effective, any plans for integrating the informal level e-waste activities into the national waste management programs must develop a framework of sustainable financial and social security for the e-waste workers, including the adoption of low-cost, socially acceptable, easy-to-operate, and cleaner technologies that safeguard the health of the workers and that of the general public. Any such plan should incorporate elements which improve the economic conditions of e-waste workers, and present alternative livelihood opportunities, which do not necessarily require acquisition of new professional skills. To this end, we propose engineering solutions which make use of local materials to construct low-cost and easy-to-operate incinerators in which the e-waste workers can burn the waste in a safe and environmentally friendly manner.

Acknowledgement

We wish to acknowledge the study participants and our expert interviewers as well as the constructive criticisms and immense inputs received from the reviewers and the editorial team which have all greatly strengthened the paper.

Disclosure

No conflict of interest disclosed.

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